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On the Concept of Industry 5.0: How Digitalization Strategies Enable Industry 5.0

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On the Concept of Industry 5.0: How Digitalization Strategies Enable Industry 5.0

The 4th industrial revolution, Industry 4.0, has transformed traditional industries with new technologies. However, the pursuit of competitiveness has overshadowed concerns for sustainability and human capital. The VUCA environment, marked by disruptions like Covid-19 and geopolitical wars, highlights the need for agility and flexibility. To address these issues, the concept of **Industry 5.0** emerges, focusing on **sustainability, resilience, and people-centricity**.

This article explores how digitalization can enhance the three pillars of Industry 5.0, specifically analysing the implementation of condition monitoring technologies in a **PROSPECTS 5.0** use case. The goal is to improve industry's overall efficiency and responsiveness.

Condition monitoring, a technique used to track the operating conditions of equipment, has played a vital role in improving productivity, reliability, and operational safety across various industries. As Industry 4.0 continues to evolve, condition monitoring has become a key technology, leveraging advancements in **IoT**, machine-to-machine communication, and smart sensors. However, its impact on **Industry 5.0**, which prioritizes **sustainability**, **resilience**, and **human-centricity**, is worth analysing.

In terms of **resilience**, condition monitoring enables the anticipation of breakdowns and disruptions, but it requires a contingency plan to be fully effective. For **sustainability**, condition monitoring can help evaluate energy efficiency and identify excessive energy consumption. Moreover, it can be used to analyse the lifecycle of components, supporting predictive analysis and eco-design[1].

Regarding human-centricity, the integration of condition monitoring techniques can be a key aspect of a people-focused strategy, essential for innovation, performance, and talent retention. It is crucial to involve all employees in the implementation and use of condition monitoring techniques, explaining the benefits and steps involved. This approach not only avoids resistance to technology but also fosters an environment where employees feel valued and listened to. By prioritizing the safety and well-being of employees, condition monitoring can put people at the centre of Industry 5.0[2]. By exploring the intersection of condition monitoring and Industry 5.0, organizations can unlock new opportunities for growth, innovation, and sustainability, while prioritizing the needs and well-being of their employees.[3]

Thanks to PROSPECTS 5.0 project, this discussion can be more tangible through the experience of one of the use cases focused on crane engineering services. This organization

[1] Murtaza, AA; Saher, A; Zafar, MH; Moosavi, SKR; Aftab, MF and Sanfilippo, F. Paradigm shift for predictive maintenance and condition monitoring from Industry 4.0 to Industry 5.0: A systematic review, challenges and case study, Results in Engineering, Volume 24, 2024, 102935, ISSN 2590-1230, https://doi.org/10.1016/j.rineng.2024.102935

[2] Deloitte. "Human Capital Trends 2021: The social enterprise in a world disrupted.", Deloitte Insights (2021)

[3] Harvard Business Review. (2019). *The business case for curiosity.* Harvard Business Review

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has implemented condition monitoring technologies through two different projects carried out together with a research centre. [4]

From their point of view, Condition monitoring is an excellent example of how these technologies can boost productivity while aligning with the pillars of Industry 5.0.

Resilience in projects can be achieved through condition monitoring, which enables the ability to adapt quickly to changes and mitigate the effects of unexpected failures. This is achieved by collecting real-time operating data, generating predictive models, and establishing preventive plans to minimize operational stoppages. Additionally, implementing redundant sensors ensures that operations are not compromised in the event of system failures, guaranteeing data availability. By defining contingency plans that can be executed automatically when failures are detected, safe operations can be maintained, ultimately strengthening the resilience of the system.

Digitalization can significantly improve **energy efficiency**, a key pillar of **sustainability**, through condition monitoring and predictive maintenance. Smart sensors detect faults and monitor energy consumption, while artificial intelligence analyses data to propose operational adjustments that minimize energy consumption. **Predictive maintenance** reduces equipment replacement, unplanned repairs, and periodic inspections, thereby decreasing material and energy consumption. Machine learning algorithms based on real-time sensor data predict future failures, enabling proactive decision-making and strengthening resilience. Additionally, integrating renewable energy sources, such as solar panels, can further reduce reliance on traditional energy sources, **lowering emissions** and **carbon footprint**.

Digitalization enables not only improved efficiency and resilience but also **more sustainable practices**, such as **eco-design**. By predicting failures, maintenance can be scheduled efficiently, reducing crane downtime and operating costs. The collected data can be used to improve future designs, reducing material usage and increasing durability, thereby positively impacting the product's life cycle. Additionally, digitalization allows for the use of 3D printing techniques and Finite Element analysis to create customized and sustainable designs. The data also facilitates the identification of frequently failing elements, enabling redesign and incorporation of circular design principles, such as recycling and reuse, to create more sustainable products.

Last but not least, **involving employees** in the adoption of new technologies is crucial for a successful transition to Industry 5.0. By engaging employees in the use of technologies such as IoT monitoring and artificial intelligence, they can confidently and effectively utilize these tools, empowering them to participate in continuous improvement. Predictive maintenance platforms simplify management and monitoring, reducing workload and allowing workers to focus on strategic tasks. Intuitive and accessible interfaces, including visual and audible alerts, enable rapid decision-making and enhance productivity and safety. A collaborative culture between operators and digital systems, where predictive analytics and data support human decision-making, is key to achieving both efficiency and safety goals, ultimately creating a safer and more efficient working environment.

[4] Gutierrez, I; Alonso, A; Gómez, L; Morella, P and Bienvenido, I. Integrated condition monitoring and maintenance optimization for sts cranes: a multi analytical approach, EPoSS Annual Forum 2024, 2024

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The future of this project holds great potential for innovation, with a focus on integrating **autonomous maintenance and operation systems**, where cranes can self-manage their maintenance processes through artificial intelligence. The creation of "**digital twins**" will also enable the simulation of crane behaviour, allowing for the prediction of failures and improvements before they occur in the real world. To achieve this, future needs include increased connectivity through **5G**, which will **enable real-time communication** of high volumes of data, and advancements in artificial intelligence for predictive analytics, leading to more accurate detection of potential failures and **optimization of the entire crane lifecycle**.

To conclude, digitization can be fully aligned with Industry 5.0 pillars improving operational resilience, energy efficiency and empowering people through new technologies. Digitization is already playing a crucial role in the evolution of industry towards a more sustainable, resilient and human-centric model, as can be seen in this use case.

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