SESSION REPORT AND SUMMARY: PREDICTIVE AND LONG DISTANCE MAINTENANCE

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1. Introduction

In recent years, the topic of predictive and long-distance maintenance has gained increasing importance. This concept is familiar to many, as it can be similar to owning a car. Typically, a car owner is prompted to visit a garage after reaching a certain mileage or after a specific period for routine checks like changing lubricants, filters, or other components prone to wear and tear. However, often during these visits, unexpected issues may arise, leading to additional repairs. This scenario illustrates two types of maintenance: scheduled or preventive maintenance and, on the other hand, corrective maintenance or repairs. Both situations can lead to dissatisfaction for the car owner. In the first case, there's a suspicion that parts or substances were replaced prematurely, incurring unnecessary costs. In the second case, the frustration stems from the inability to use the car, especially if it breaks down at a crucial time, a phenomenon humorously referred to as "Murphy's Law." This brings us to the question: Is there a smarter solution to these maintenance challenges? The answer lies in predictive maintenance, a focus of this session. This session report summarizes and discusses three presentations on this topic.

2. Soil Tillage: Predictive Maintenance in the Agritech World

Presenter: Andrea Ruffin (Maschio-Gaspardo, Italy)

2.1. Problem Statement

In the evolving landscape of agriculture, the increasing scale of farms and the shrinking windows for agricultural operations due to climate change are significant challenges. These changes require agricultural machinery to deliver maximum performance consistently, necessitating efficient maintenance strategies. Predictive maintenance in agriculture, particularly in soil tillage, aims to identify and address potential equipment failures, reducing downtime and improving overall productivity.

2.2. Types of Maintenance

The spectrum of maintenance strategies employed in agriculture is below.

- **Reactive Maintenance**: This approach involves the replacement of components upon failure, practical when spare parts are accessible.
- **Preventive Maintenance**: A proactive strategy, informed by historical data to schedule maintenance operations before likely failures.
- **Condition-Based Maintenance**: Integrating sensor technology, this method relies on real-time and historical data to signal when replacements are necessary.
- **Predictive Maintenance**: This technique combines historical data analysis with real-time monitoring through extensive sensor usage, to predict the remaining lifespan of machine components.
- **Prescriptive Maintenance**: An advanced approach that uses a comprehensive sensor array, predicting potential system-wide failures.

2.3. Key Enabling Technologies

Essential technologies for predictive maintenance include various sensors for monitoring temperature, vibrations, and other parameters. Enhanced data processing capabilities on machinery are crucial, reducing the volume of data sent to the cloud. Artificial Intelligence algorithms and cloud computing play pivotal roles in analysing data and predicting potential failures. The concept of 'Digital Twins'—virtual replicas of physical assets—helps analyse real-world data, improving maintenance strategies.

2.4. Practical Implementation and Challenges

The focus of Maschio-Gaspardo's implementation strategy lies in high-value machinery, where component failure can have significant repercussions. Ruffin discussed the intricacies of finding a viable balance between the costs of advanced sensor technologies and the benefits they bring in predictive maintenance. Implementing these technologies presents several challenges, primarily the costs associated with sensors, artificial intelligence, and cloud computing. Ruffin emphasized the need for multidisciplinary collaboration, incorporating expertise from data science, machine learning, cloud architecture, and mechanical engineering. Furthermore, he addressed the complexities surrounding data privacy, a particularly acute issue in the European context due to stringent regulations and the sensitivity of agricultural data.

2.5. Future Research and Applications

Future research involves collaborations with academic institutions to develop hybrid digital twins and optimize sensor applications. There is a push towards creating accessible data storage solutions for farmers, potentially leading to unified data storage across different agricultural machinery manufacturers.

3. Combined physical and AI-based predictive maintenance for components

Presenter: Walter Lehle (Robert Bosch, Germany)

3.1. Overview and Background

Walter Lehle's presentation from Robert Bosch GmbH emphasized a synergistic approach to maintenance, harmonizing techniques from both the automotive and agricultural sectors. This unified strategy is important in addressing the complex challenges of modern machinery maintenance, integrating diverse technological perspectives for a comprehensive maintenance strategy.

3.2. Integration of Electronic and Software Components

The discussion highlighted the critical role of integrating electronic and software components in modern maintenance practices. This integration is not merely a juxtaposition of hardware and software but a harmonious fusion that leverages the strengths of each to enhance system predictability and functionality. It is important to note that how this synergy leads to more intelligent, responsive, and efficient maintenance solutions, capable of adapting to evolving technological landscapes.

3.3. The Digital Twin Concept in Predictive Maintenance

A significant focus was on the digital twin concept in predictive maintenance. This approach involves constructing virtual models of physical systems for simulation and analysis. These models predict component behaviour and system interactions, serving as a tool for preventing maintenance issues and enabling a deeper understanding of machinery dynamics. The digital twin is instrumental in reducing unforeseen maintenance scenarios and enhancing overall system efficiency.

3.4. Advanced Maintenance Strategies: AI's Role in Evolution

The evolution of maintenance strategies from conventional methods to advanced AI-driven approaches was thoroughly examined. This transition is characterized by an increasing reliance on data analytics and machine learning algorithms. These algorithms enhance maintenance scheduling and predict component performance accurately, exemplifying a paradigm shift in predictive maintenance, focusing on data-driven insights for informed decision-making.

3.5. Practical Applications: Case Studies on Battery Maintenance

The practicality of these advanced maintenance strategies was illustrated through detailed case studies focusing on battery maintenance. These studies included both low and high voltage batteries, emphasizing how data collection, physical modelling, and AI techniques are employed to monitor battery health. The case studies demonstrated the tangible benefits of predictive maintenance in reducing downtime and optimizing maintenance schedules.

3.6. Challenges in AI Model Implementation

Implementing AI-based predictive models is fraught with challenges, as elucidated by the presenter. These include the necessity for an in-depth understanding of the physical and electrochemical properties of components, along with the requirement for extensive data collection and sophisticated data processing techniques. The integration of these elements into an effective predictive system is crucial for realizing the full potential of AI in maintenance.

3.7. Future Outlook and the Need for Integrated Systems

The presentation concluded with a forward-looking perspective on predictive maintenance, emphasizing the critical need for integrated information systems. These systems are essential for consolidating diverse data sources and interfaces into a unified, user-friendly platform. The effective implementation of predictive maintenance technologies relies heavily on the ability to integrate and interpret vast arrays of data, underscoring the importance of information accessibility and system integration for future advancements.

4. The human factor in a data-driven service process: support vs. supervision for CLAAS tractors

Presenter: Axel Holtkotte (Claas GmbH, Germany)

4.1 Introduction to Data-Driven Service in Agricultural Machinery

The evolution of the service process over the past decade has transformed from a linear model to a more interconnected system, influenced by the integration of connected machinery. This change has altered the traditional roles of machine owners, dealers, technicians, and manufacturers. The evolution of data-driven service processes in the context of agricultural machinery, particularly focusing on CLAAS tractors, was examined. The role of data analysts in managing diverse field data types, ranging from warranty and inspection data to telemetry data critical for predictive maintenance, was outlined, setting the stage for a deeper exploration of service processes.

4.2. Impact of Connectivity on Service Process Dynamics

An in-depth exploration was presented on the role of connectivity in revolutionizing the service process for agricultural machinery. The advent of connected machines heralded a new era in maintenance practices, facilitating proactive interactions among stakeholders and leading to the adoption of predictive maintenance methodologies. This section examined how such connectivity enables the preventive addressing of potential mechanical issues, often before they manifest visibly, thus heralding a significant shift from reactive to proactive maintenance approaches.

4.3. Challenges in Adopting Predictive Maintenance: Mindset and Operational Shifts

Inherent challenges associated with the adoption of predictive maintenance in agricultural machinery are related to mindset shifts among stakeholders such as resistance to change and trust in technology. A critical focus was placed on the mindset shift required amongst stakeholders, particularly emphasizing the need to convince machine operators of the benefits of preventive maintenance and interventions in the absence of immediate mechanical failures. The discussion highlighted this mindset change as crucial for leveraging the comprehensive benefits of predictive maintenance, including enhanced operational efficiency and reduced long-term breakdown risks.

4.4. Human Involvement in Data-Driven Service Processes: Strategy and Adaptation

The necessity for a comprehensive approach to the implementation of data-driven service processes was emphasized. This approach goes beyond traditional data collection and algorithmic analysis, demanding a significant reorientation in mindset and the development of an integrated digital service strategy. The effectiveness of AI and data-driven solutions in agricultural machinery maintenance is positioned as being heavily dependent not only on technological capabilities but also on the adaptation and acceptance by human operators. This section emphasized the need for a holistic strategy that incorporates human factors alongside technological advancements.

4.5. Case Study: Trust and Transparency in Customer Engagement

A case study was presented to illustrate the practical challenges and nuances in customer engagement within data-driven service processes. This case study involved a farmer's reaction to remote maintenance suggestions based on data analysis and highlighted the complexities of maintaining trust and transparent communication. The scenario underscored the delicate balance required in handling sensitive customer data and the imperative of maintaining trust for the successful adoption of data-driven service practices.

5. Summary of Panel Discussion and Q&A

The panel discussion covered a comprehensive range of topics related to predictive maintenance, user behaviour, data utilization, and the challenges and opportunities in the machinery industry.

Key Points Discussed:

- The discussion began with an exploration of Type 1 and Type 2 errors in predictive maintenance, emphasizing the balance between being overly cautious and ignoring potential red flags. This balance is crucial in avoiding excessive alarms that may lead to the disregard of genuine warnings.
- Examples from modern machinery highlighted the issue of diagnostic trouble codes being ignored by users, often due to visibility and connectivity limitations. This illustrated a commonality in user behaviour across different contexts.
- Implementing predictive maintenance poses several challenges, including the limited use of high-cost sensors and the need for a soft sensing approach to reduce costs while maintaining effectiveness.
- Issues related to data sharing, privacy laws, and the difficulties in transferring data across different stages of the supply chain were addressed. The role of industry and other institutions in educating and guiding users about technology and process management was also discussed.
- The growing demand for the right to repair in the United States and the implications for sharing diagnostic data for maintenance purposes were debated, highlighting both the economic and practical aspects of this issue.
- The meeting concluded with a discussion on the future of technology dissemination, industry responsibility, and the potential for more efficient and user-friendly maintenance approaches.