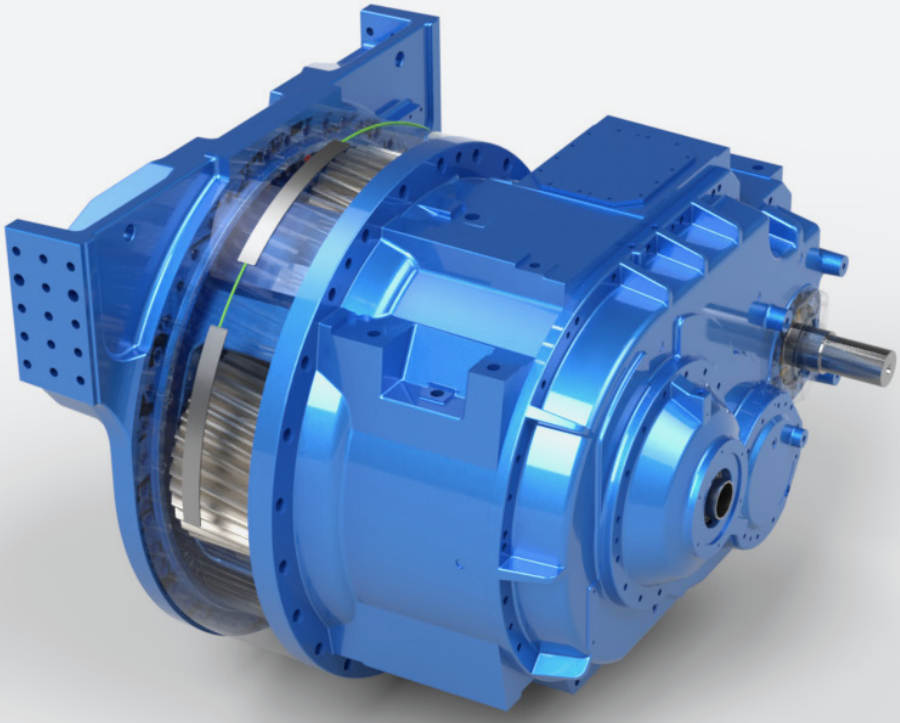

Taking a data driven approach to turbine maintenance

Sensing360's innovative optical sensing technology enhances condition based maintenance and reliability based maintenance by integrating real time load data for precise failure prediction in wind turbines. The company's Cofounder and Chief Operating Officer, Eric van Genuchten, explains to PES how this approach optimizes maintenance, reduces costs, and boosts wind farm efficiency for operators.

PES: It's great to welcome you back, Eric. Last time we featured Sensing360, back in our first edition of 2024, we focused on how gearbox integrated optical sensing is redefining the way gearboxes and drivelines are monitored and measured, for increased reliability. It would be useful to our readers, I think, to focus this time on your condition based maintenance (CBM) and reliability based maintenance (RBM), if we may?

Eric van Genuchten: Thank you for having us back at PES. It's great to be able to share the progress we've made since our last conversation.

You're right that CBM and RBM are at the heart of what we're doing. The wind energy industry is evolving rapidly, and operators are under increasing pressure to maximize uptime, reduce costs, and improve the overall efficiency of their wind farms. By shifting from traditional, time based maintenance schedules to data driven, condition based approaches, we're empowering our customers to make more informed decisions about when and how to maintain their equipment.

PES: How does your cloud based solution differ from traditional CBM and RBM systems?

EvG: At the heart is GearUp, a fiber optical load sensing system, mounted on the stationary outer ring of a planetary gearbox that acts as a data feed. Our solution with secure cloud connectivity sets itself apart by incorporating real time, operational load data into the condition monitoring equation.

Unlike traditional CBM and RBM systems that primarily rely on vibration analysis and temperature readings, we offer a more holistic view of the gearbox's health. By understanding and by measuring the actual loads a gearbox is subjected to, we can accurately predict its remaining useful life, optimize maintenance schedules, and prevent unexpected failures. This physics informed data driven approach significantly enhances the precision and effectiveness of our CBM and RBM strategies and bases the prediction on actual use.

PES: Everything that rotates fails over time of course, so how does your solution estimate the remaining usable life (RUL) of components?

EvG: Estimating the RUL of components is a critical aspect of our solution. Failure is defined by the component's capacity to endure and accumulate damage; it depends on how much it walked and how much it carried in the past. We gather this information by feeding our lifetime models with real time load data, creating a 'consumed capacity' indicator. This, coupled with the continuous monitoring of actual loads, allows us to predict the remaining useful life for each critical component with its probability of failure.

This information empowers wind farm operators to plan maintenance proactively, based on anticipated fatigue failure risks, and simulate different maintenance strategies to avoid costly breakdowns and maximize the return on their investments.

To help our customers with this new parameter, we offer a base assessment, asset due diligence, of their gearbox health and 'consumed capacity' for free based on past data to show the value.

PES: Could you explain how your system derives the probability of failure for rotating components?

EvG: We leverage historical data on component performance, including load profiles, operating conditions, and failure patterns. By correlating this information with real time data from the gearbox and fatigue lifetime models, we can estimate the probability of failure of the gearbox, its components, and even of the complete powertrain.

Apart from fatigue failures, irregular gearbox running and early signs of failures can be identified by monitoring load and load sharing, or direction, trends showing anomalies that indicate potential issues. Our algorithms then assess the severity of these anomalies and calculate the likelihood of component failure.

PES: What types of sensors and data collection methods do you use to monitor the condition of gearboxes and other critical components?

EvG: At the core of our monitoring system is our innovative use of optical fiber Bragg grating (FBG) sensors. These sensors are strategically placed on the fixed frame of the gearbox, eliminating the need for complex wiring or telemetry and batteries. This not only simplifies installation and maintenance but also ensures the system's reliability and longevity.

The FBG sensors measure strain, temperature, and vibration, providing a comprehensive assessment of the gearbox's condition. By utilizing light based technology, our sensors are inherently immune to electromagnetic interference, making them exceptionally robust in the harsh environment of a wind turbine. This ensures the accuracy and consistency of the data collected, enabling us to deliver precise insights into component health.

PES: Can you explain how your solution detects early signs of failure, and what specific metrics or indicators are monitored?

EvG: We focus on critical parameters such as gearbox torque, planet load sharing, and vibration data. So actually, adding application load as a new metric. By closely monitoring these metrics, we can identify subtle changes that signal potential issues with gears, teeth, and bearings but also non optimal operating conditions like unbalance are detected.

Eric van Genuchten

For instance, abnormal load sharing patterns can indicate incipient, bearing damage, while specific vibration frequencies can pinpoint bearing wear or gear damage. Our physics based algorithms continuously analyze these data points to detect deviations from normal operating conditions. By combining these values, we can detect more gearbox failures and more ahead of time compared to conventional solutions, saving up to 400 k€ on maintenance per 50 turbines per year.

PES: You mentioned that your solution sets a new standard for condition monitoring, as quoted by the Uptime Podcast. What unique features or technologies have you implemented to achieve this recognition?

EvG: We're honored to have been recognized by the Uptime Podcast, and key differentiators include our load monitoring capabilities, and advanced prediction monitoring parameter as load sharing. Coupled with gearbox and bearing life models, we can accurately simulate and predict component behavior under various operating conditions. Combining this with secure cloud connectivity enables real time data analysis and accessible insights, empowering operators to make data driven decisions swiftly. This approach, combined with our robust and reliable FBG sensor technology, has allowed us to achieve a level of predictive accuracy that is new in the industry.

PES: What customizable features or analytics does your dashboard offer to help users make informed maintenance decisions?

EvG: Our dashboard is designed to empower users with actionable insights through a range of customizable features and analytics. We provide critical metrics such as probability of failure, and time to failure at the gearbox components, turbine, and park levels, enabling operators to implement a truly risk based maintenance strategy.

Beyond these core metrics, our dashboard offers flexibility in data visualization and reporting, allowing users to tailor the

information to their specific needs. Whether it's tracking performance indicators, identifying trends, or comparing different turbines, our integratable platform provides the tools to make informed decisions.

PES: Would you say that your solution has the potential to increase total park utilization and performance?

EvG: Yes, absolutely. Our ability to assess the real time load on each turbine allows for dynamic load management strategies. Turbines that are operating under less stressful conditions can potentially be pushed to higher output levels, maximizing energy capture. Conversely, turbines experiencing heavier loads can be monitored more closely to prevent premature failures. This intelligent approach to load balancing not only increases energy yield but also extends the overall lifespan of the wind farm and accommodates 7% more power output during the lifetime.

PES: Explain the steps that are taken to ensure that the data and insights provided by your system are accurate and reliable.

EvG: Data accuracy and reliability are fundamental to the value we deliver. Firstly, our FBG sensors are renowned for their precision and stability, delivering highly accurate raw data. Rigorous calibration and validation processes are conducted before sensor deployment and at regular intervals.

Secondly, our data transmission protocols are designed with redundancy and security in mind. Data is encrypted and transmitted through secure channels to our cloud platform. Robust data validation checks are implemented at every stage to identify and correct anomalies.

Thirdly, our physics based algorithms and life and prediction models undergo rigorous testing and validation using both historical and real time data. We continuously monitor the performance of our models and adjust as needed to maintain accuracy.

Finally, we collaborate closely with our customers to gather feedback and refine our system. By combining these elements, we are confident in the accuracy and reliability of the data and insights provided by our solution.

PES: Are collaboration and support from customers crucial for understanding their specific needs and enabling you to tailor your solution accordingly?

EvG: Customer collaboration and support are key to success with any new solution. Understanding the unique challenges and goals of each customer is essential for tailoring our solution to deliver maximum value. We believe in a strong partnership approach, working closely with our clients to identify their specific needs and develop customized solutions.

PES: How do you see the field of condition monitoring evolving over the next few years, and what role will your company play in that evolution?

EvG: We anticipate a future where condition monitoring becomes increasingly sophisticated and integrated into the broader ecosystem of wind farm management. The industry will move towards more predictive and prescriptive maintenance models, driven by advancements in computing power enabling artificial intelligence, machine learning, and digital twin technologies.

At Sensing360 we believe in using this technology in a transparent way by adding physics based models to it. To make things easier for our customers, we will expand our capabilities to include new components beyond the gearbox, such as the complete powertrain, including the main bearing and generator, and pitch bearings.

Through strategic partnerships, we aim to extend our monitoring solution to cover the entire wind turbine, providing a holistic view of asset health and performance. This holistic approach will enable wind farm operators to make even more informed decisions and maximize the return on their investments.

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