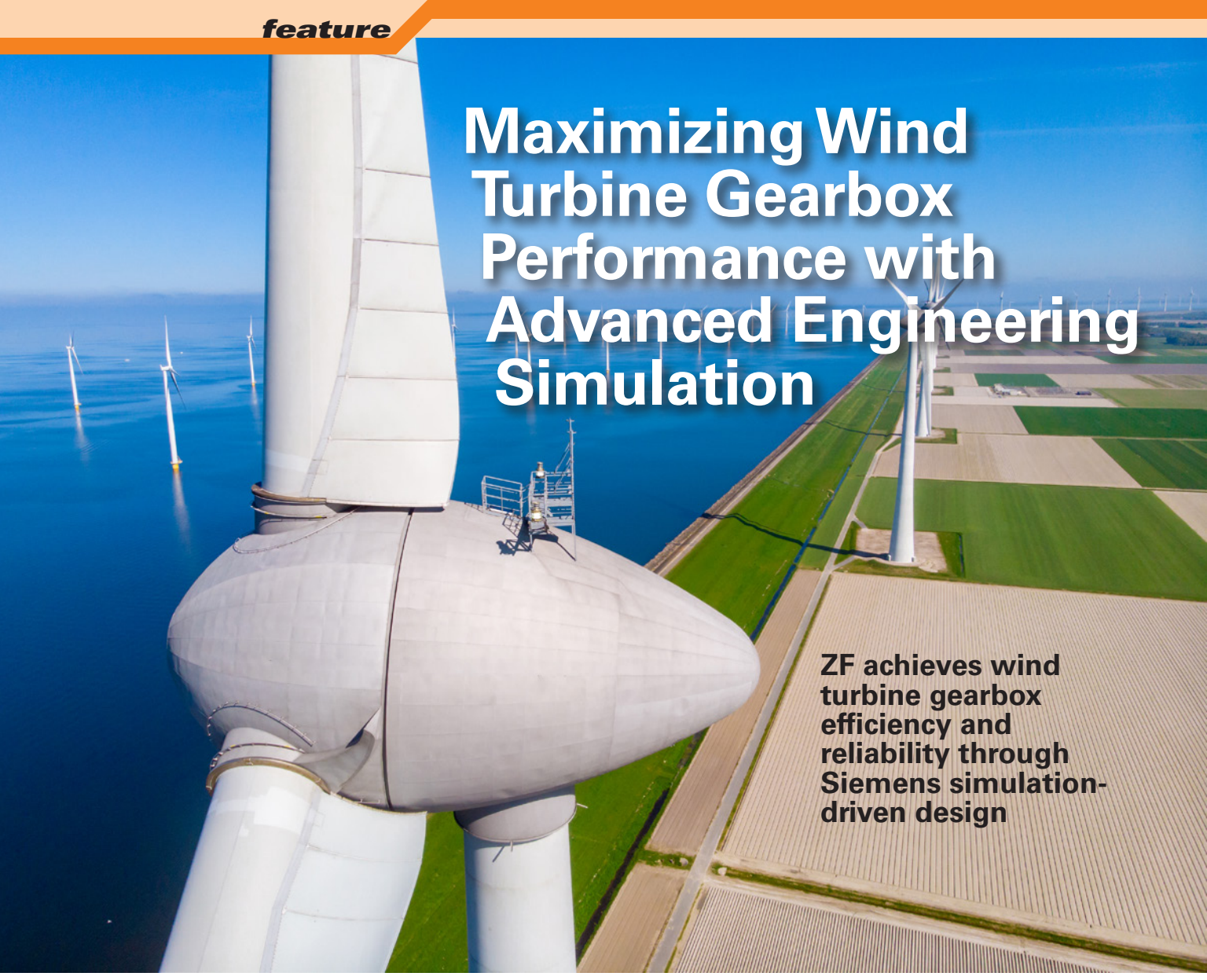
Maximizing Wind Turbine Gearbox Performance with Advanced Engineering Simulation



ZF achieves wind turbine gearbox efficiency and reliability through Siemens simulation-driven design

Siemens* Simcenter *solutions can replace tedious and time-consuming calculation with system-level simulation in wind applications.

Wind power has emerged as one of the most important sources of renewable energy in recent years. The global wind power capacity was estimated to be 837 gigawatts in 2021 (*statistica.com*). In the United States alone, wind is the largest source of renewable electricity, providing 10.2 percent of the country's electricity and still growing (*cleanpower.org*). However, to ensure maximum power generation, the efficiency and reliability of the wind turbine are critical.

Wind turbines are complex machines with several core components, such as blades, towers, gearboxes, and direct drive motors. The gearbox is responsible for converting the low rotational speed of the blades to the high-speed rotation required to generate electricity. Due to complex dynamic loads, the high-speed rotation in wind turbines can generate a large amount of heat in the bearings and gear mesh contacts. This heat can impact gearbox performance and durability, making it crucial for engineers to introduce simulation-driven design to identify potential issues and develop effective cooling strategies.

Balance heat generation with cooling and lubrication networks

ZF Wind Power has implemented Siemens *Simcenter Flomaster* software, a system-level thermo-fluid simulation tool, to streamline their engineering design processes and improve the productivity of their teams.

A business unit of ZF Friedrichshafen, ZF Wind Power is a leader in designing, manufacturing, supplying, and servicing wind turbine gearboxes.

Prior to implementing the *Simcenter* software, ZF Wind Power relied on Excel spreadsheets to calculate the appropriate flow rates and pressures of the gearbox flow paths. According to Jo Loenders, product management engineer, ZF Wind Power, this was "a very complex and time-consuming process, as the distribution systems for the lubrication can involve hundreds or even thousands of small components that result in pressure losses."

Simcenter Flomaster allows engineers to quickly validate the models since each component comes with validation data and results. "With the ability to determine flow rates and pressures anywhere in the model, the verification of the system against

Simcenter Flomaster ***software offers a system-level thermo-fluid simulation tool. The software offers built-in empirical data, a large library of components and sample systems to boost engineering efficiency.***

test data from flow measuring devices under realistic circumstances is easy," said Loenders.

In addition, the software includes built-in empirical data, a comprehensive library of components, and sample systems to enhance engineering efficiency. According to Loenders, "the use of *Simcenter Flomaster* allows a significant streamlining of the development process. From the very beginning, creating the fluid model is easy and intuitive."

Using strategic testing and simulation to reduce gearbox weight

As wind turbines increase in size and power output, the gearboxes required to handle the increased torque and rotational speed also increase in size and weight, posing significant transportation and installation challenges. Gearbox manufacturers can optimize the design process to reduce weight by introducing advanced engineering simulation and test methods early in the design phase. This allows engineers to evaluate the gearbox's performance and reliability under real-world operating conditions and identify any potential issues or areas for improvement before the product is released to the market.

Moventas, a leader in wind turbine gearboxes, has successfully used Siemens *Simcenter Testlab* software and *Simcenter* SCADAS hardware for high-speed data acquisition, testing, and design troubleshooting.

The company aimed to engineer a lightweight gearbox that minimized vibrations and develop components for higher input torque while reducing size, weight, and cost.

According to Jari Toikkanen, head of research and development, manager of conceptual design and analysis, Moventas, "by implementing a strict, step-by-step simulation and testing measurement procedure, we offer our customers an extremely reliable design process as well as gearboxes with superb product properties delivered within a very competitive time-to-market timeframe."

In addition, given the new regulations in the wind energy industry, smaller and more compact gearbox designs have made torsional dynamics a key consideration. Turbine manufacturers must gain a thorough understanding of the gearbox's behavior and internal dynamics under different operating conditions. "You need to know exactly how it behaves," Toikkanen explains. "This is a key aspect of a reliable machine. The wind turbine

driveline consists of many components. It is known that the dynamics factors inside the turbine components can differ even 15 percent from simplified rotor loads." The key is to use simulation software to understand these loads, and then confirm the results with a robust testing procedure which involves validating specific torsional dynamics and structural deflections.

Over the past decade, Moventas has honed its design process to perfection, resulting in 10 tons of weight reduction in its gearbox design.

Wind gearboxes are a critical part of the turbine as they translate relatively slow-moving rotation from the large blades to a much higher rotational speed needed for the onboard electrical generator.

A holistic approach to design

Wind turbine manufacturing is a complex process that requires precise engineering and manufacturing techniques. Because of the intricate dynamic loads, the turbine components can occasionally malfunction, leading to high lifecycle costs.

In addition, the energy industry is grappling with multiple challenges, including market volatility, supply chain issues, increased regulations, and geopolitical tensions. To keep pace with the changing industry landscape, siloed approaches to managing projects are no longer sufficient. What's needed is a holistic approach to integrate all processes within a comprehensive digital platform to tackle the increased complexity of gearbox design.

By integrating advanced engineering simulation into their design phase earlier, engineering teams can gain better understanding of the intricate physics involved in gearboxes and identify potential issues early on, reducing costly iterations while accelerating application development. In addition, once inefficient processes are identified, they can be improved to reduce the environmental impact of the manufacturing process. Thanks to the digital twin, the entire process chain can be digitalized, allowing companies to drive faster time-to-market at a lower cost.

The *Simcenter* portfolio is a crucial component within *Siemens Xcelerator*, a comprehensive and integrated portfolio of software and services from Siemens Digital Industries Software. The *Xcelerator* portfolio of solutions is designed to help businesses create and leverage a comprehensive digital twin that provides organizations with new insights, opportunities, and levels of automation to drive innovation.

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Simcenter Flomaster also helps reduce the design time required to size distribution lines to achieve the required flow rates. In wind turbine gearboxes there is always more than one flow path that requires fluid flow.