CASE STUDY

MODELING NEXT-GEN WIND TURBINES

ALTAIR SOLUTIONS MONITOR AND OPTIMIZE VERTICAL WIND TURBINES

Background Information
Wind energy is the most effective, well-established renewable energy source today. It has far fewer deleterious effects on the environment than many other energy sources, especially compared to fossil fuels. However, complex systems like the wind turbines needed to generate wind energy require regular inspections and maintenance to ensure an effective, long-lasting service life. This is where digital twin technology, with its real-time analysis and prediction capabilities, can deliver immediate, impactful value.

About the Customer
The National Institute of Technical Teachers Training & Research (NITTTR) Chandigarh, is an autonomous educational institution under the government of India's Ministry of Education (MoE). NITTR aims to be a leading institute for promoting excellence in the technical education system.

As a part of its digital program initiatives, NITTTR has set up multiple lab activities as part of its official training curriculum, including programs on digital twin, embedded artificial intelligence (EAI), and virtual reality.

NITTTR is focused on introducing digital twin models and including them in its curriculum, where during the courses students and faculty can better understand the importance and impact of implementing digital twin by blending simulation and Internet of Things (IoT) technology.

Their Challenge
As part of their digital twin program, NITTTR needed to include a practical model that was representative of real-life scenario. This model needed to include sufficient complexity in both its design and operation. To create such a model required a technology platform that enables users to create a digital twin that addresses both physics and data. A model like this would help users better understanding the model on the operations side and thereby provide insights on future design requirements. To cover this, NITTTR felt that a wind turbine would be an ideal real-world scenario to analyze. They chose Altair to develop this model.

97% ▲
OVERALL ACCURACY

4.5% ▼
MAXIMUM MARGIN OF ERROR

Digital Twin Platform: A unique convergence of physics simulations, data analytics and AI/ML

NITTTR chose to model wind turbines because they are complex machines that face unique challenges. For example, wind turbines' manufacturing, installation, and maintenance costs are high. Wind turbines also face harsh, continuously changing weather making their maintenance schedules unpredictable. Routine maintenance, regular inspections, and real-time analysis are vital steps that ensure wind turbines remain functional and effective throughout their service life. These characteristics make wind turbines an ideal candidate to base a digital twin on.

Our Solution

A digital twin is a digital representation of a physical object, process, or service such as a wind turbine, jet engine, robotic arm, or even buildings. It enables real-time communication between physical and virtual models, and can be used to simulate a physical system for various purposes such as performance testing, installation, predicting health conditions, etc.

Altair's digital twin solution is ideally suited to create an accurate virtual model of a wind turbine. With its range of technology to address both physics- and data-driven twins – and the ability to analyze both a projects' engineering and operational aspects – Altair's solutions were uniquely capable of addressing NITTTR's requirements. NITTTR also took advantage of Altair's robust domain expertise to further define the model and expand the scope of the project. This allowed NITTTR to better teach digital twin technology.

For NITTTR, a physical vertical axis wind turbine was set up, commissioned, and connected with various sensors, accelerometers, strain gauges, and anemometers. The sensors were also calibrated and interfaced with a computer system running Altair machine learning and CAE software.

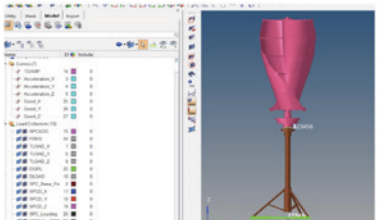
From there, the calculations involving the wind turbine's digital twin were performed using Altair Embed®, Altair® RapidMiner® data analytics platform, Altair® HyperGraph®, and Altair® OptiStruct®. These tools span data acquisition, modeling, data visualization and processing, and finite element (FE) modeling and analysis. Since wind turbines are mostly located in remote areas, these tools are useful because they allow users to access real-time data remotely via IoT technology. Applying the real-time data to the virtual models, teams and organizations can better predict and make decisions about maintenance schedules using the wind turbine's digital twin thanks to Altair's solutions.

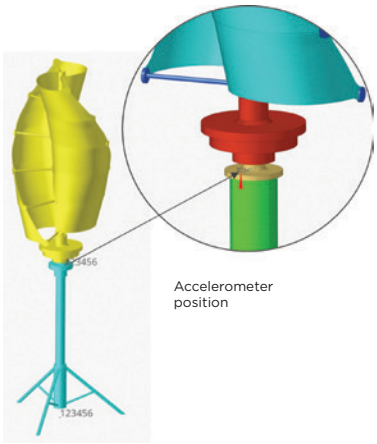
Results

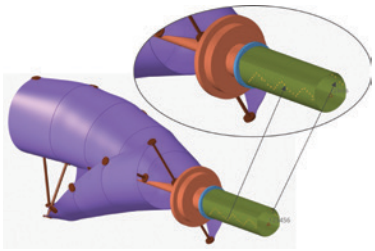
With Altair's digital twin solutions, NITTTR was able to continuously observe the virtual wind turbine's parameters – thus improving the physical asset's performance and illustrating the basic concepts of digital twin technology to students and users alike. Thanks to Altair technology, NITTTR was able to leverage a machine learning model developed using two data sets consisting of 18,000 tests collected using an accelerometer and a strain gauge. The data comprised of a set of healthy data and another data set collected by introducing fracture in the structure to record faults. Overall, the model was able to predict the "good" condition of the wind turbine structure with an accuracy of 97%, and the "faulty" condition of the wind turbine structure with an accuracy of 95%. By applying different excitation frequencies on the FE model for healthy and faulty structures, the observed physical strain closely matched the experimental result.

In conclusion, digital twins are here to stay, and their adoption by the wind energy sector will accelerate in the coming future with improved cost-cutting and efficiency as well as safety. Overall, Altair's technology helped NITTTR achieve its learning and teaching goals and accurately illustrated the basic concepts of digital twin technology to all involved.

To learn more about Altair's digital twin solutions, please visit **altair.com/digital-twin**







TOP: Finite element (FE) model of windmill.
MIDDLE: Data Fusion: Enforced excitation in FeModel vs accelerometer position.
BOTTOM: Results: Observed strains FE vs experimental.