

Case Study



Boosting the Efficiency of Wind Power Plants

■ *By Steffen Schenk and Wolfgang Steindorf*

Three-dimensional measurement and analysis of rotor blades and their production facility are highly complex and demanding measuring tasks. The nature and scope represent an entirely new dimension in this branch of industry. Consequently, such a task can be coped only by using ultra-modern measuring systems and a correctly prepared measurement strategy. An investigation of suitable measuring systems on the basis of the specific requirement profile for this measurement task indicated that the Leica Laser Tracker provides the best preconditions for successful measurements.

Stringent Demands for Boosting the Efficiency of Wind Power Plants

Further development of wind power plants and their components with the aim of boosting the useful energy is a very dynamic process. One essential factor is the optimization of the rotor blades, a factor, which has substantial impact on the functionality and efficiency of the plants. A rotor blade length of 38 m has now been reached (Figure 1). In future, lengths of approx. 80 m are to be implemented on the planned offshore plants. These ever-increasing sizes and the requirement for mass production of the rotor blades, which are designed on the basis of aerodynamic principles, true-to-detail, necessitate a quali-

ty assurance system whose performance and efficiency must be adjusted constantly.

Optimizing Rotor Blades by Precise Measurements

Reliably inspecting the non-uniform, spherically curved objects and their production facilities and, if necessary, deriving corrective actions, may pose tremendous difficulties for manufacturers. The reason are the limits to the use of conventional aids such as templates and gauges. This led the NOI-Rotortechnik GmbH company, with its headquarters in Nordhausen/Germany, to contact Engineering Consultants Schenk & Steindorf GbR. Their staff have been

The Successful Analysis of Wind Turbine Rotor Blades

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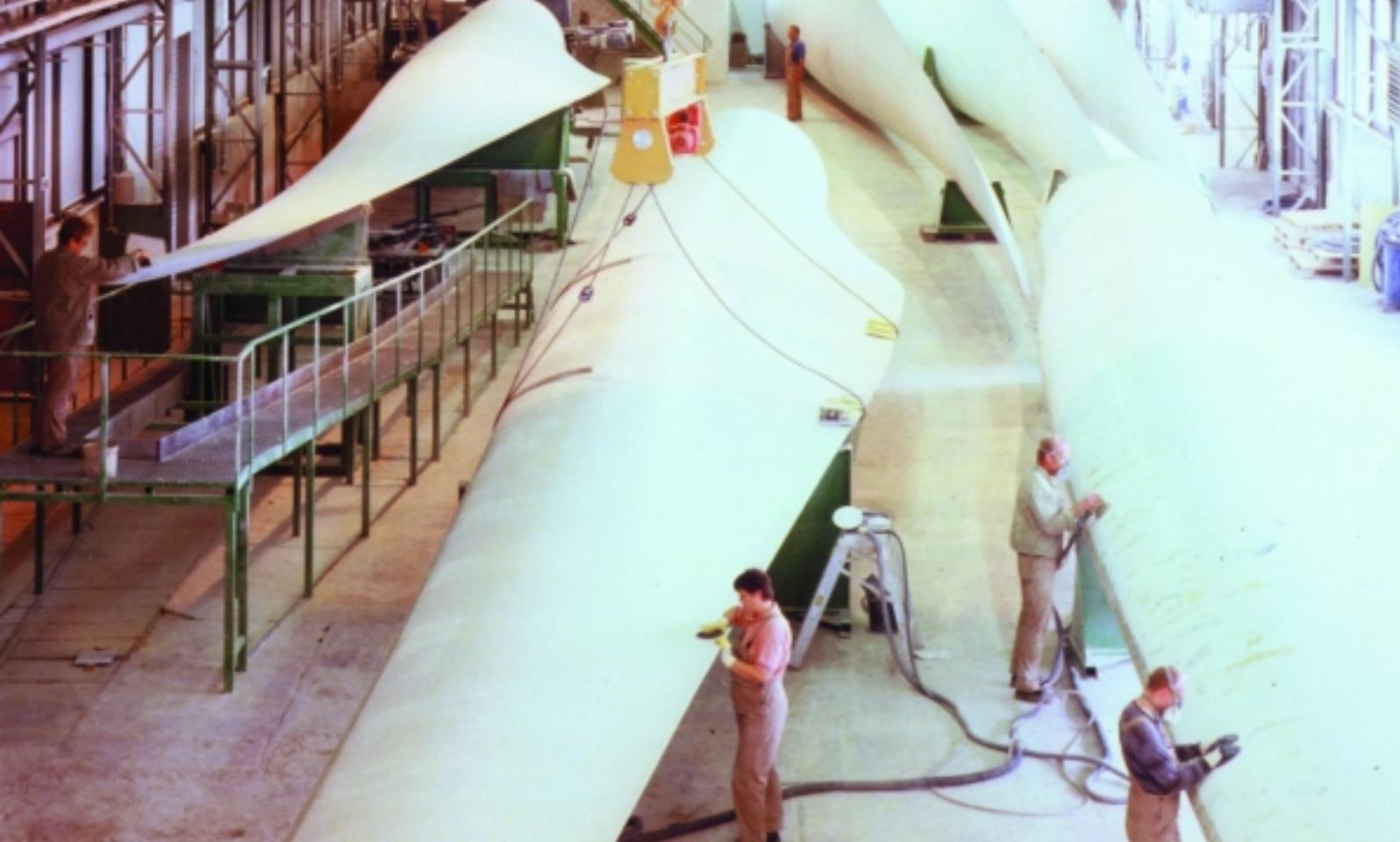


Figure 1: Rotor blade production at NOI-Rotortechnik GmbH

specializing for some years in exact measurements of large-volume objects, e.g. modern ICE trains. Appropriate solutions for the demanding measuring tasks were sought together with this consulting company.

Using the Laser Tracker LTD500 manufactured by Leica Geosystems, one of the most modern optical 3D measuring systems for large objects, enables a quantum leap in efforts to describe the geometry of the rotor blade, both qualitatively and quantitatively with a high and reliable degree of accuracy.

Selection of a Suitable Measuring System

During the preparation phase, the engineering consultants compared various alternatives of possible measuring systems.

The following requirement criteria were established as the basis for assessment of the methods:

- Acquisition of 3D coordinates
- Large measurement volume (approx. 40 m x 10 m x 5 m)
- High measuring accuracy
- High point density since the components are spherically curved
- Mobile use
- Comparison with CAD model
- Precise documentation of the results

The following systems, which are all used for industrial precision measurements of large-volume objects were analyzed with regard to their suitability:

- Theodolites/total stations
- Videogrammetry/photogrammetry
- Laser Tracker

The Leica Laser Tracker, which ideally covers the entire spectrum of the requirement profile and whose measurement options provide sensible support for the specific measurement task was assessed as optimum for use in rotor blade measurements.

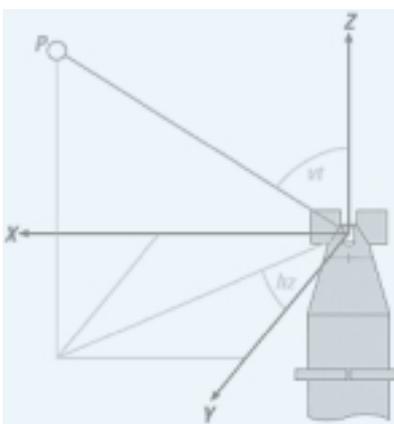


Figure 2: Polar coordinate measurement

The Successful Analysis of Wind Turbine Rotor Blades

Find the Best Solution to Virtually any Conceivable Task

The Leica Laser Tracker Fulfills the Requirements Best

The Leica Laser Tracker provides 3D coordinates of a reflector mounted in a small steel sphere by measuring the following values (Figure 2):

- Horizontal angle
- Vertical angle
- Distance

During measurement, the reflector can be "tracked" automatically by means of a motor system while the reflector is moved in space or guided manually by the operator over the object to be measured.

Measurements of the Rotor Blades and the Production Facility

The measurement of the object can be categorized as very complex and difficult. The reasons for this relate to the lack of traceable "inner" coordi-

nate systems and the required high measuring accuracy, besides the tremendous size and the spherically curved shape of the component.

The aim of measurement was to inspect the entire geometry, in particular the area of the leading edge. The length of the rotor blade was approx. 35 m with a maximum spread of 3 m x 2 m. By agreement with the specialists at NOI, the rotor blade was split over its length into thirteen measurement sections, each with a width of approx. 1 m. This provided a manageable number of measurement points and helped to systematically interpret the results.

Three different locations of the measurement system were required in order to perform the measurement of the entire rotor blade with unobstructed line of sight to all measuring points (Figure 3).

Each 3D measurement is based on the local coordinate system of the object corresponding to the design documentation. The sole reference to this was the flange area, both on the rotor blade and on the production facility. Consequently, each session started with the measurement and analysis of the flange area from the first location. (Figure 4). The object points in the individual areas and the orientation points were then acquired. The so-called Corner Cube was used as reflector.

After all object and orientation points were measured from the first location, the system was moved to the next location. Using the orientation points from the first location the new location was mathematically transferred into the original object coordinate system. From now on all new object points were recorded in the original coordinate system as used in the first location.



Figure 3: Measurement situation on the production facility



Figure 4: Measurement of the flange area on the rotor blade



Figure 5: CAD model of the rotor blade

**Analysis of the Measurement Data:
Comparison With the Design Data**

Overall, approx. 20'000 points were acquired, both on the rotor blade and on the production facility. To manually evaluate such quantities of data with feasible effort, in particular on spherically curved components, is impossible. It is therefore necessary to digitally compare the recorded measuring points with the CAD model (Figure 5).

The density and number of measured points allow various options in geometrical analysis. One practical approach is to perform a breakdown into large global geometrical errors (deflection phenomena and twist etc.) and smaller, local geometrical errors (dents, bulges and scoring etc.). This could be achieved by different comparisons of the measured points to the CAD model.

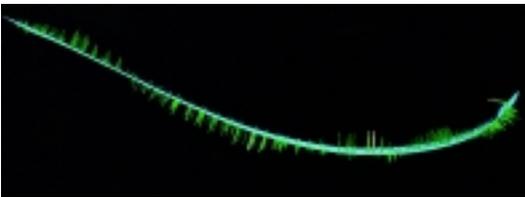
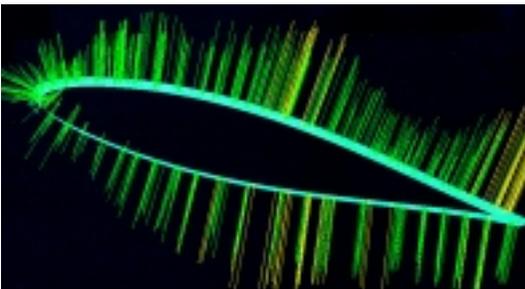
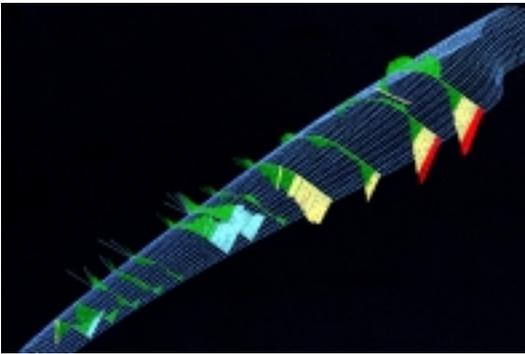
In a first step, all measured points of the whole blade were aligned ideally with respect to the CAD model. The subsequent nominal to actual comparison provided information on the global geometrical errors of the object.

This made it possible to establish a direct interrelationship between the actual geometry of the production facility and the object and to quantify deflection phenomena and twist on the object. This, in turn, enabled precise adjustment of the production facility on the basis of the measurement results.

In a second step the local geometrical errors were evaluated. For this purpose, the measured points were aligned separately and successively for each section with respect to the CAD model. By subsequent nominal to actual comparisons of the individual measurement sections the long-wave deflections and twists of the rotor blade could be filtered out and specific information on dents, scoring and the quality of e.g. the leading edge could be evaluated. (Figure 6 to 8).

Despite the tremendous measurement volume, a measurement uncertainty of approx. + 0.3 mm was achieved.

This means that the actual geometry of the object and also the information on its deviations from the CAD model proved very reliable.



Figures 6 to 8: Graphical representations of the local deviations



Outlook

The increasing sizes of wind power plants and the growing demands for higher accuracy of the individual subassemblies necessitate to a greater extent the use of ultra-modern measuring systems.



Figure 9: Dimensional inspection of blade hubs

The successful analysis of rotor blades and other parts (Figure 9) indicates that also in other branches of industry the extended use of optical precision measuring systems will substantially contribute towards an optimized and stabilized production.

One other important aspect is the option of reliably verifying and documenting the quality of the products. This creates margins of certainty especially in a sector characterized by distributed production.

The Laser Tracker measuring system used for this job combines many positive characteristics. The most important of them are:

- High accuracy and thus reliability
- Large measuring range
- High measurement rate (dynamic measurement)
- Direct CAD comparison

There are other conceivable applications for optical measuring systems applied for measuring rotor blades, tower sections, machine elements (Figure 9) or production facilities and for analyzing damage.

Every measurement task must always start with the selection of an appropriate measuring method. The broad spectrum of differing characteristics of the various systems makes it possible to find the best solution to virtually any conceivable task.





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