Optical Measuring Techniques
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Application Example: Quality Control

Turbines: Measuring Turbines with ATOS and TRITOP

Measuring Systems: ATOS, TRITOP
Keywords: Reverse Engineering, complete turbines, single blades

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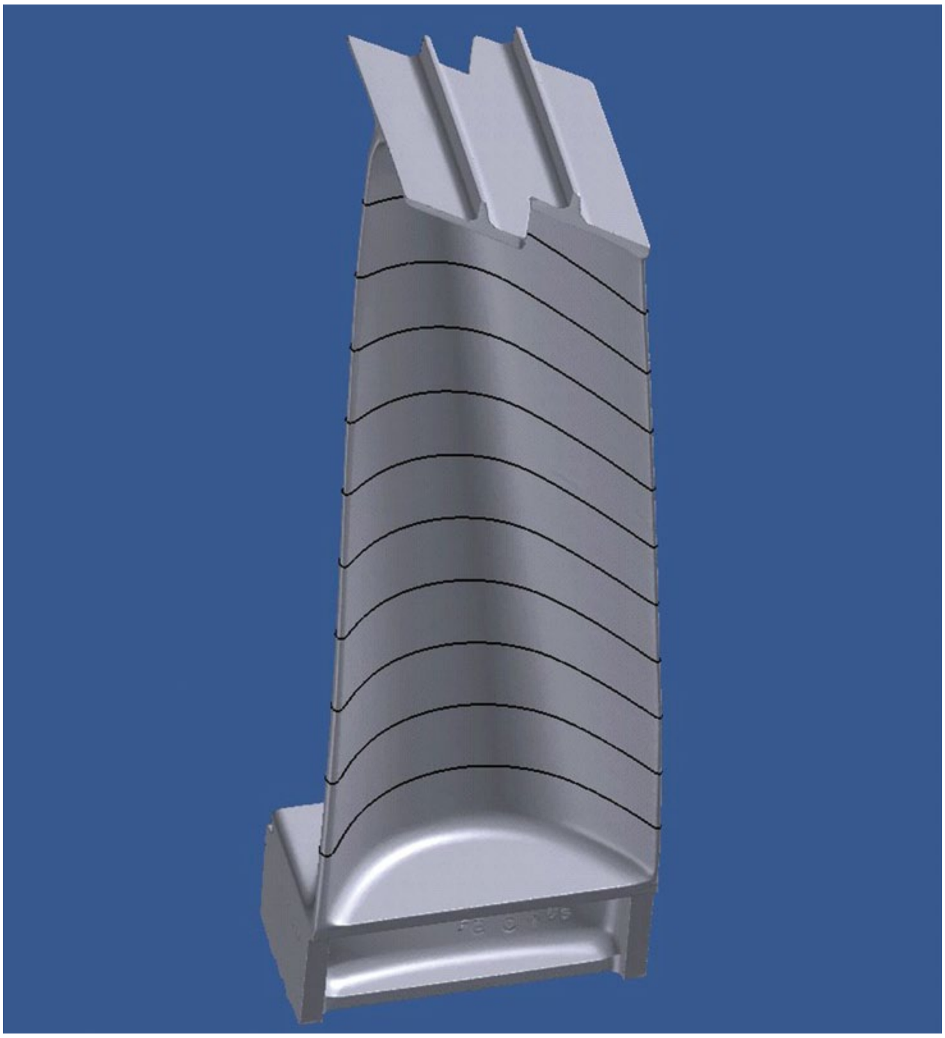

GOM mbH
Mittelweg 7-8
38106 Braunschweig
Germany
Phone +49 531 390 29 0
Fax +49 531 390 29 15
info@gom.com

GOM International AG
Bremgarterstrasse 89B
8967 Widen
Switzerland
Phone +41 5 66 31 04 04
Fax +41 5 66 31 04 07
international@gom.com

GOM France SAS
10 Quai de la Borde - Bât A2
91130 Ris Orangis
France
Phone +33 1 60 47 90 50
Fax +33 1 69 06 63 60
info-france@gom.com

GOM UK Ltd
Business Innovation Centre
Coventry, CV3 2TX
Great Britain
Phone +44 2476 430 230
Fax +44 2476 430 001
info-uk@gom.com

GOM Branch Benelux
Interleuvenlaan 15 E
3001 Leuven
Belgium
Phone +32 16 408 034
Fax +32 16 408 734
info-benelux@gom.com

Quality Control / Turbines

Measuring Turbines with ATOS and TRITOP

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Turbine blades and other components of stationary generators and aircraft engines in most cases have complex geometries and freeform surfaces. Therefore, measuring their geometry is quite demanding with respect to the measuring equipment and measuring strategies. Depending on the application, measuring technology requirements might be very different.

Optical measuring systems like ATOS, providing for full-field digitizing of the entire object, are much more flexible than pointwise measuring methods. While these measuring methods generally output individual points or provide results along sections, optical systems allow for capturing the entire geometry. This characteristic feature particularly meets the requirements of new manufacturing and repair procedures for turbine blades as well as of new quality standards. Thus, complete and fast measuring of components considerably optimizes the time for product and production development as well as for production launch and control. The entire process from development to production can be accompanied time-effectively and remains transparent.

Reverse Engineering of Turbines and Turbine Blades

The repair or reproduction of older turbines and blades or of those made by other manufacturers, is a problem for engineers as drawings or CAD data are missing. Measuring these parts completely using coordinate measuring machines is particularly time-consuming.

The optical digitizing system ATOS, however, digitizes objects of any size and complexity fast, precisely and completely, see figure 1.

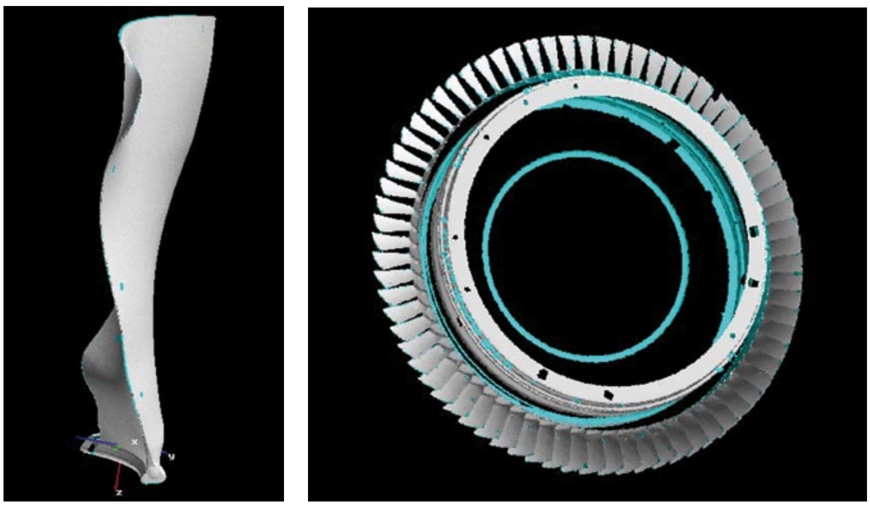

Fig.1: Digitized large and small turbine blades including details like cooling channels and entire blisks

The results are available instantly in a polygon mesh, the so-called STL mesh. This mesh shows a very high resolution in all areas of strong curvatures such that fine details like the leading and the trailing edge are exactly reproduced, see figure 2.

Fig.2: STL data of a turbine blade at the leading edge, section

For surface reconstruction, the STL data as well as sections made of them (see figure 3) can be imported into software for surface reconstruction or in common CAD systems. Any design changes may then be made to the surfaces thus created. In addition, the STL data can directly be imported and processed in CAM systems to create NC programs. This procedure provides current data sets for all turbine components which were not or just insufficiently documented within a short time, and production or repair can start using today's methods.

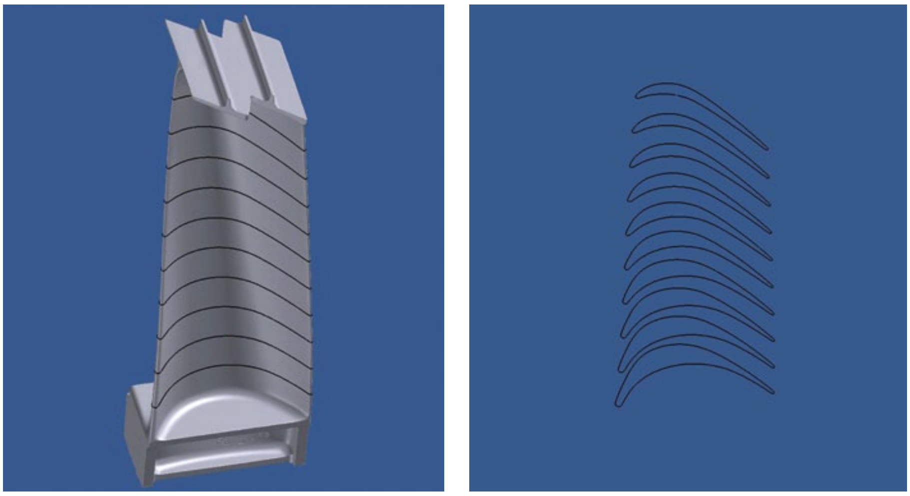

Fig.3: Sections of digitized data

In addition, the STL data can be used for stability and flow simulations. It is a particular advantage that the simulations are based on data of real parts and not on theoretical or constructed parts.

In addition to turbine components, larger turbines or complete groups of assembled turbines can be digitized using a combination of ATOS and TRITOP. The photogrammetry system TRITOP provides the position of the components in their assembled state which are then 100% digitized with ATOS - if required in a disassembled state as well. The data correspond to a digital mock up, see figure 4.

Fig.4: Digitized parts of a turbine, data, reconstructed CAD data

As the ATOS system stands out for its compact design and its mobility, measurements can be performed at different places. It is even possible to measure spots that are hard to reach like in water turbines. The high precision of the ATOS system and the little time needed to carry out measurements, offer engineers new points of view when working with assemblies that are not documented.

Analysis in Production Development and Launch

The optimization of time for production development and production launch is a decisive factor for competitiveness. Measuring the geometry of the product is required in almost every production step and in each iteration stage. The measured data are compared with the nominal geometries (of CAD data or master parts).

The common procedure to measure components on coordinate measuring machines requires a measurement plan, i.e. the areas (measuring points) in which the analysis is to be carried out have to be defined well in advance. However, a great number of measuring points involves a lot of time whereas the determination of measuring points prior to measuring is superfluous when using the ATOS system for the fast and complete measurement of objects. The deviations over the component's entire geometry are clearly visualized in color and are easy to understand even for outside observers, see figure 5.

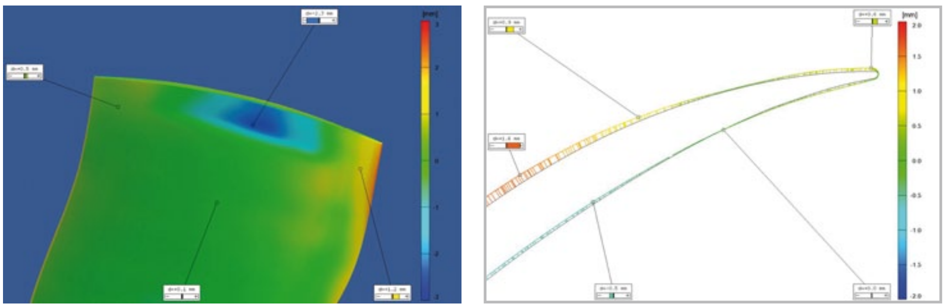

Fig.5: Color representation of deviations, sections, labels

In addition, user-defined reports containing sections, labels and much more, support the interpretation and the understanding of the analysis results. At any time - i.e. also after measuring is completed - specific points on the object may be determined, and the deviations for these points can be documented in tables or evaluated statistically with repeated measurements of parts that are identical in construction.

The available functions provide for creating standard measuring protocols at any time.
Various methods are available to align the measured data to the nominal geometry of the components, allow for analysing local geometry deviations but also visualize torsion or deformations of partial areas with respect to each other.

If the alignment is made to the aerodynamic part (airfoil) of the turbine blade, the actual deviations in these areas can be analysed. If, however, best-fit registration is performed to the root of the turbine blade, torsion of the airfoil with respect to the root can be detected.

Other registration or coordinate transformation rules like 3-2-1 or RPS registration which uses reference elements like planes, holes, cones, cylinders and much more allow manifold individual solutions.

Fixtures, measured with TRITOP, which are used for the components or turbine blades, guarantee a reproducible positioning of these parts, and coordinate transformation after measuring is no longer necessary. The ATOS system measures directly in the defined coordinate system using the reference point markers of the fixture.

For analysis, components can be measured completely or partially with ATOS in each production step in order to
- Determine the geometry of blanks. This guarantees that subsequent processing can be carried out properly. It is also possible to consider the blank's geometry when creating processing programs (e.g. milling paths). This reduces the processing time.
- Exactly check the dimensional consistency after cutting processes.
- Check the dimensional consistency or the deformation after heat treatments.
- Measure and assess dents and bumps on airfoils.
- Check the layer thickness when applying protective and insulating layers. The comparison of measurements before and after coating, aligned to the root of the turbine blade, result in the layer thickness.
- Check the mounting of components, e.g. the mounting of individual turbine blades to a blisk.

When repairing turbine blades, ATOS measurements may be used to:
- Document the blades' geometry before and after weld cladding.
- Check the dimensional consistency after processing.

Inspection in Production
Pointwise measuring methods come close to their technical limits because of the increasing requirements regarding quality in production like a larger amount of measuring points, flexible measuring solutions for a variety of products as well as precise measuring equipment. Optical full-field measuring methods, however, provide high flexibility and very dense measuring points.

To measure large quantities of components, an automated solution supported by a robot and combined with a rotation table as an option would be best, see figure 6. ATOS provides extensive macro programming to automate the entire measuring procedure including the control of the handling systems and evaluation up to generating a yes/no statement or a report.

Thus, for example, measuring the aerodynamic contour of a turbine blade is done in less than 30 seconds.

Fig.6: Digitizing a turbine blade, ATOS sensor with robot and rotation table

Summary

Optical digitizing of turbine blades and other turbine components offers new possibilities in product and production development as well as in production quality control.

Features like:

- time saving during measurement,
- complete measuring,
- support of new manufacturing processes,

increase the competitiveness of the user due to a higher quality and shorter development times.

Therefore, optical digitizing with the ATOS system is an essential part of the so-called "Time Compression Technologies".