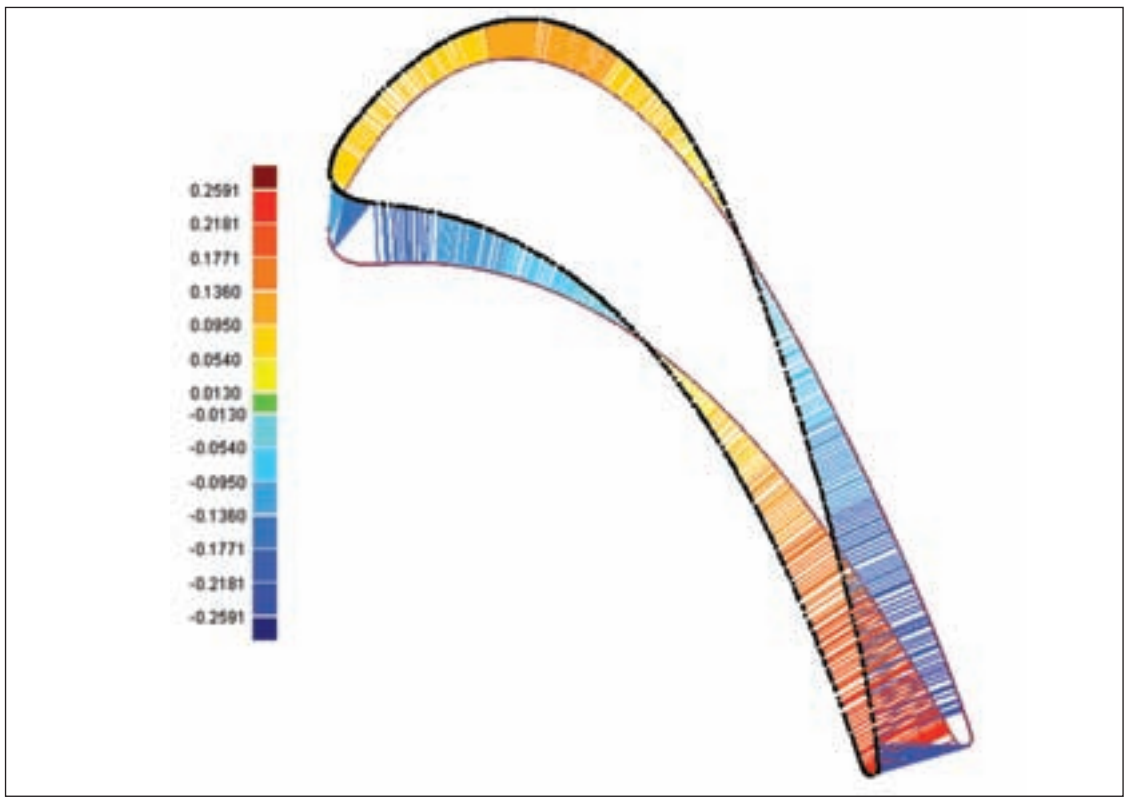

Measurement edge

Optical measurement system and computer aided software cut turbine blade inspection times by up to 70%. at Alcoa Howmet.

Major improvements to the inspection process at Alcoa Howmet's foundry in the south west of England have been enabled by the introduction of a GOM ATOS II optical measurement system and Geomagic Qualify computer-aided inspection software.

"What used to take us a week or more we can now complete in one day," says Steven Edwards, layout and tool room manager at Alcoa Howmet's foundry near Exeter in the south west of England.

What he is referring to is the proof inspection of newly-cast turbine blades and other airfoil components; a process which has been transformed with the introduction of digital shape sampling and processing (DSSP) and computer-aided inspection software from Geomagic.

Previously known as Howmet Castings, Alcoa Howmet is one of the two divisions that make up Alcoa Power and Propulsion, a major business unit of Alcoa Inc. Serving the aerospace and industrial power generation equipment manufacturing industries, Alcoa Howmet's products range from castings of super-alloy, titanium and aluminium alloys, to equipment and materials for the investment casting industry. At its foundry near Exeter the company casts turbine blades and vanes for world-class companies such as Siemens, Alstom, Rolls Royce and ABB, among many others.

The components it produces for these customers are cast using the lost-wax, or investment casting process. Briefly, the process works like this. Patterns of the castings to be made are moulded by injecting a special wax into a metal die. At Alcoa Howmet these dies are produced by external tooling suppliers using digital 3D solid models supplied by the customer and evaluated by Alcoa Howmet's product engineers. Cores of pre-formed ceramic, to create special voids within a cast part, may be incorporated into the wax patterns as they are moulded. Individual patterns are then assembled into a cluster around a wax runner system.

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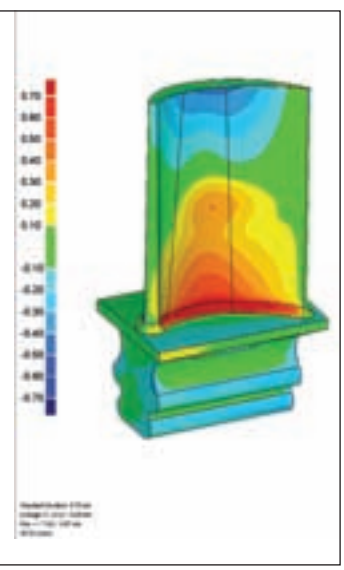


This 'tree' of patterns is then coated with several layers of a refractory material, each layer being dried or chemically cured before the next layer is applied.

The assembly tree is heated to remove the wax and is then fired at high temperature to bond the refractory mould strongly. The hot mould is then filled with molten metal. When cool, the mould material is removed, by impact, vibration, grit or high pressure water blasting, or chemical dissolution, leaving the castings, which are then removed from the runner system.

According to Alcoa Howmet, the investment casting process has several distinct advantages over other manufacturing methods when it comes to the types of product it manufactures for its customers. For example, castings can be manufactured with complex features, such as 3D contours, thin walls and undercuts, while control of the process variables enables closer tolerances to be achieved. It is also an economical process for both prototype and production run quantities.

Nevertheless, as with any other manufacturing process, distortions of the cast parts can occur. So the inspection process is key to Alcoa Howmet's ability to produce parts that meet all geometric tolerance conditions and are to the high quality expected by its customers.

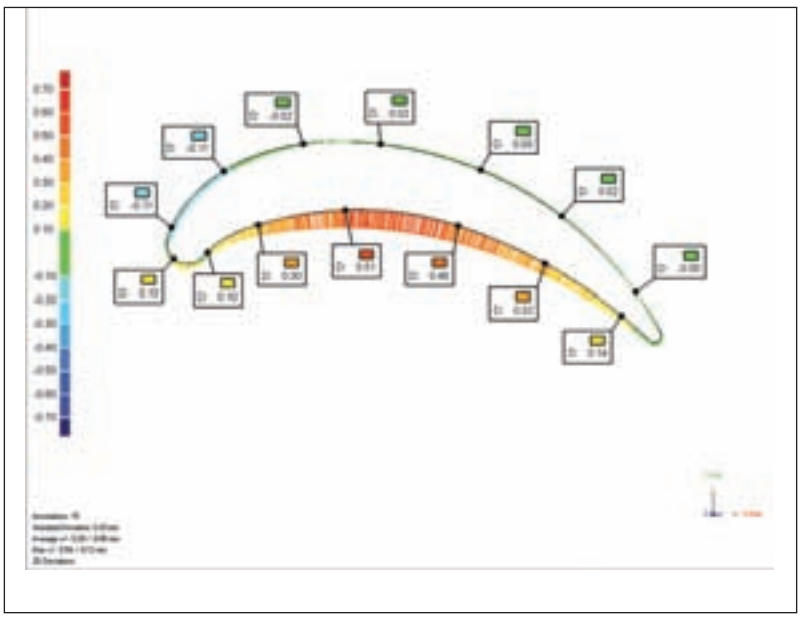
From days to hours.

Today that inspection process, both for first-article and for changed parts inspection, relies mainly on new digital shape sampling and processing (DSSP) technology. DSSP is a category name that encompasses the convergence of multiple technology advances. It describes the ability to use scanning hardware and processing software to digitally capture physical objects and automatically create accurate 3D digital models with associated structural properties for design, engineering, inspection and custom manufacturing.

At Alcoa Howmet's Exeter facility, the DSSP technology used comprises a GOM ATOS II optical measurement system, which captures part geometry as a dense 'point cloud' or polygon mesh that precisely describes an object's surface and primitives, and Geomagic Qualify computer-aided inspection software.

The ATOS II system digitizes a physical part by projecting different fringe patterns of white-light onto the object's surface. These patterns are captured by two cameras located at either side of the projector. As the object is scanned, the areas in which measurements have been recorded are displayed on a computer screen.

The system monitors its calibration and the effects of the environment to ensure reliable meas-



urement in rough industrial conditions. The captured data is then imported into Geomagic Qualify for the inspection process.

Geomagic Qualify takes advantage of digital shape sampling and processing to enable fast, easy-to-understand graphical comparisons between CAD models and as-built parts. It saves time and increases accuracy for first-article inspection, trend analysis, 2D and 3D dimensioning and automated reporting. It has helped Edwards and his team in Exeter to reduce proof inspection cycle times to typically one day from the week or more that it took with the earlier touch-probe coordinate measuring machine (CMM)-based methods in use.

The inspection process itself relies on two inputs: the 3D scan data of the part to be inspected and the original 3D CAD model of the part. Both are read into Geomagic Qualify, using industry-standard data transfer methods, or directly in the case of the data from Alcoa Howmet's Unigraphics CAD system. Datums and features upon which the inspection is going to be based are then created on the CAD model. The scan data is then aligned with the nominal CAD model using both the manual and the automatic alignment facilities provided by Geomagic Qualify.

Once the scan data and the CAD model are aligned correctly the inspection process starts. This includes overall three-dimensional analysis of any deviation between the physical part and the nominal CAD model, with the results being presented as a colour-shaded plot of the part, showing deviation values. Areas of the part that fall outside assigned geometric tolerances are also displayed for easy identification, along with geometric dimensioning and tolerance (GD&T) call-outs, whisker plots of cross-sections and wall thickness analysis results.

Alcoa Howmet also takes advantage of the specialised inspection capabilities offered with Geomagic Blade, an optional extension to Geomagic Qualify. Geomagic Blade focuses on the turbine machinery industry, providing specific functionality to enable the analysis of rotors, stators, impellers and specific internal blade features.

"With the Blade extension we can readily undertake multiple airfoil analysis by analyzing and reporting on dimensions related to turbine segments, such as minimum opening, or throat, and minimum distance blade to blade, as well as other turbine-specific inspection requirements such as twist analysis and cross section and chord length measurements," says Matt Willacy, Alcoa Howmet layout engineer and Geomagic Qualify user. "What's more, the software is easier to use and faster than our earlier system and Geomagic is always willing to listen to our needs and to come up with new capabilities."

Easy-to-understand reports.

But carrying out the inspection process is only part of the story. Reporting the results to the product engineers so that any required changes to the wax patterns that the inspection process might have identified can be carried out is equally important. In the past, this reporting procedure has always proved to be something of a bottleneck as the reports were time-consuming to produce and difficult to understand.

"The use of Geomagic Qualify has not only speeded up the actual inspection process but also the production of the reports," states Willacy. "They contain both graphical representations of the inspected part, such as colour-shaded deviation plots, etc., as well as actual numerical values, so they are much easier to understand than the reports we used to produce".

Images for the reports are created by saving required views during the inspection set-up procedure. Reports are then output automatically and can be in a number of standard formats, including HTML, PDF and Microsoft Word. The Alcoa Howmet team in Exeter currently outputs them as PDF documents which are then printed off for use by the product engineers. However, Steven Edwards has plans to install the free Geomagic Review software on all engineers' PCs to give them easy access to reports by downloading them over the network. This will enable the engineers to further analyze the part and interrogate the results.

Something else that speeds up the process is the ability to produce inspection templates within Geomagic Qualify. These templates are customer-specific and are produced by saving the inspection workflow created the first time a part is inspected. The same workflow is then applied to subsequent inspections at the touch of a button and a separate report for the new part is produced, again automatically. This use of inspection templates means that set-up time is reduced to the absolute minimum.

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