µCMM Application Note

Full Report available at: https://bit.ly/2L7eJux

Internal measurement of cooling holes in turbine and compressor blades

Bruker alicona

Bruker Alicona is a leading global supplier of optical metrology solutions based on the principle of Focus Variation.

Focus Variation works based on moving a focal plane over a surface and collecting robust 3D data which can then be used to measure geometric form and surface finish from a single optical sensor.

Measurement processes can be fully automated and provide GD&T measurement capabilities across all industrial & medical sectors.

The systems are in use in industry, industrial research, universities and production facilities globally.

www.alicona.com

Introduction:

Turbine engines operate under increasingly high temperatures for maximum exhaust velocity and optimum efficiency. Internal temperatures reach up to 2000°C and exceed the melting point of turbine blades. To prevent self-destruction an advanced cooling system with up to 500 specially shaped cooling holes are embedded through the turbine blades. These holes circulate a thin, turbulent layer of air between the combustion gasses and blades. They are essential for safe and long-term use of the engine.

It is critical that each cooling hole corresponds exactly to the CAD data set in regard to angle, size, position and shape. Cooling holes are freeform and therefore enormously complex to measure.

Conventional metrology techniques do not provide the solution for internal hole measurement in terms of geometry and finish, additionally, the hole entry geometry can be more complex with tapered entry points as shown in Figure 1 below.

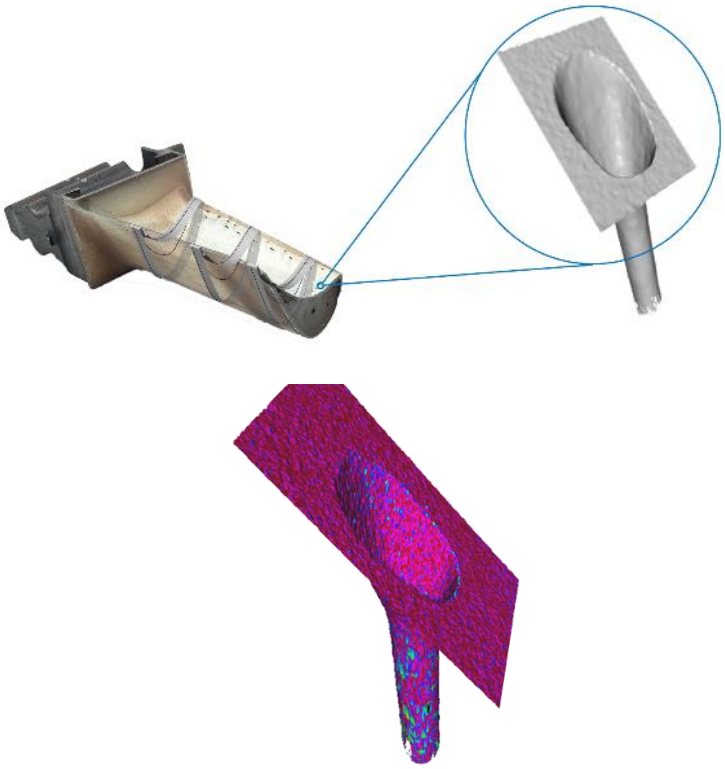


Figure 1

These measurement challenges are now solved by the Bruker Alicona optical Focus Variation technique adapted with Vertical Focus Probing. This technique allows holes with depth-to-diameter ratios up to *10-1* to be internally measured and is briefly described below. The full paper on Vertical Focus Probing is available here: https://bit.ly/38GJz6t

Vertical Focus Probing is based on the use of partial light. This means that in addition to coaxial light, light from different directions is used. As a result, individual light rays diffusely reflected from vertical surfaces are captured again by the objective, enabling the traceable and repeatable measurement of flanks with more than 90° in a high-resolution.

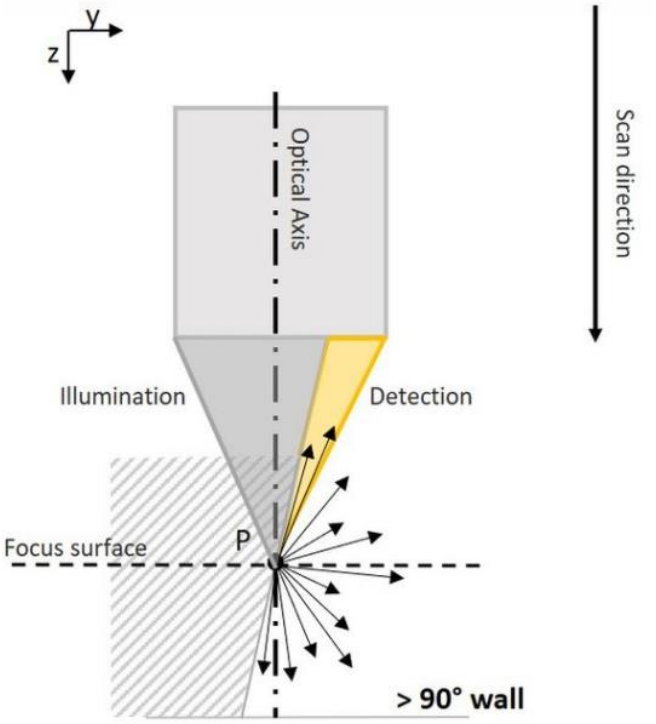
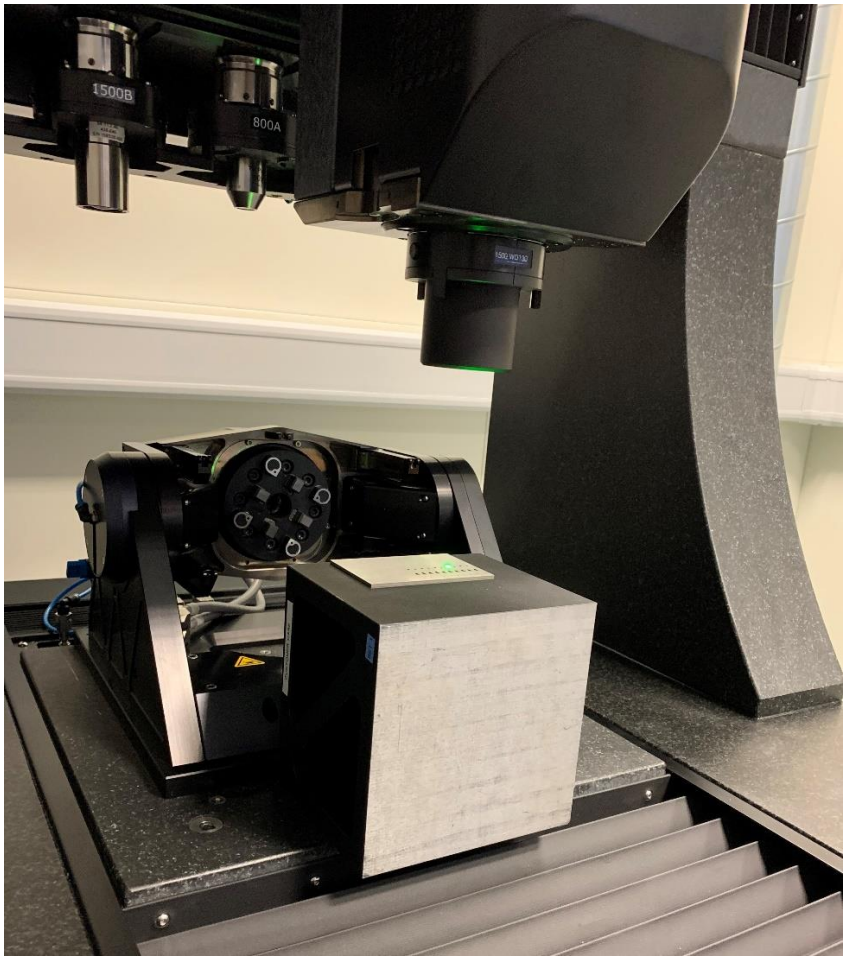


Figure 2

Cooling Holes in Compressor Blades have different positions and orientation. This often makes it difficult to reach and measure a hole due to the working distance of the Objective. Therefore, Bruker Alicona has developed an objective with a working distance of 130 mm which overcomes this restriction.



In this case a test plate with a series of EDM holes was created, illustrated in Figure 3. These holes represent typical holes used in cooling hole applications.

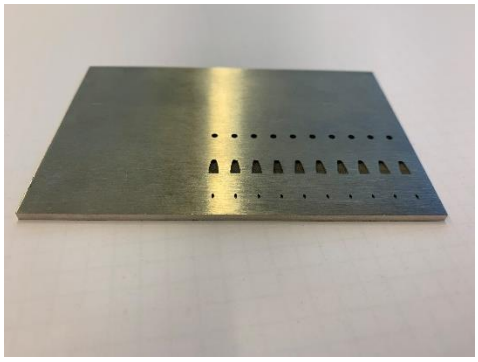


Figure 3

This plate is held in an AR3D rotation device mounted on a Bruker Alicona µCMM.

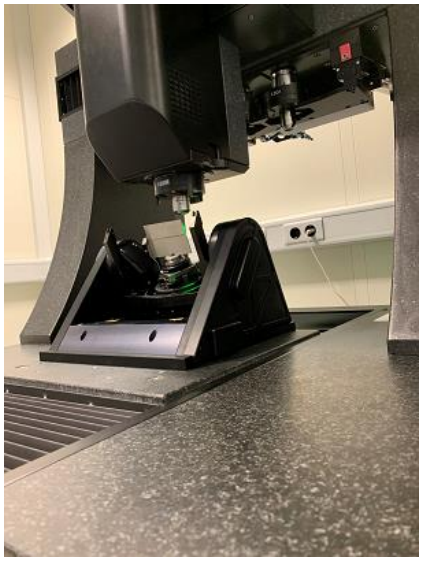


Figure 4

Using Vertical Focus Probing it is then possible to create a 3D dataset of the inside of the hole.

The first parallel hole illustrated below has a diameter of 534 µm and a length of 2.2mm.

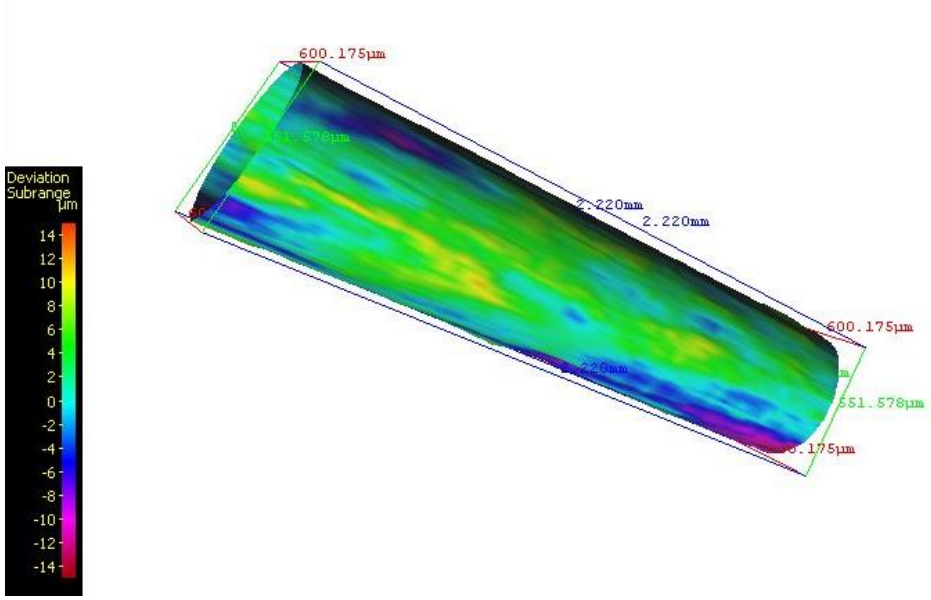


Figure 5

The second tapered entry hole illustrated in Figure 6 shows the capability to measure shaped hole geometry and perform measurements along its whole length.

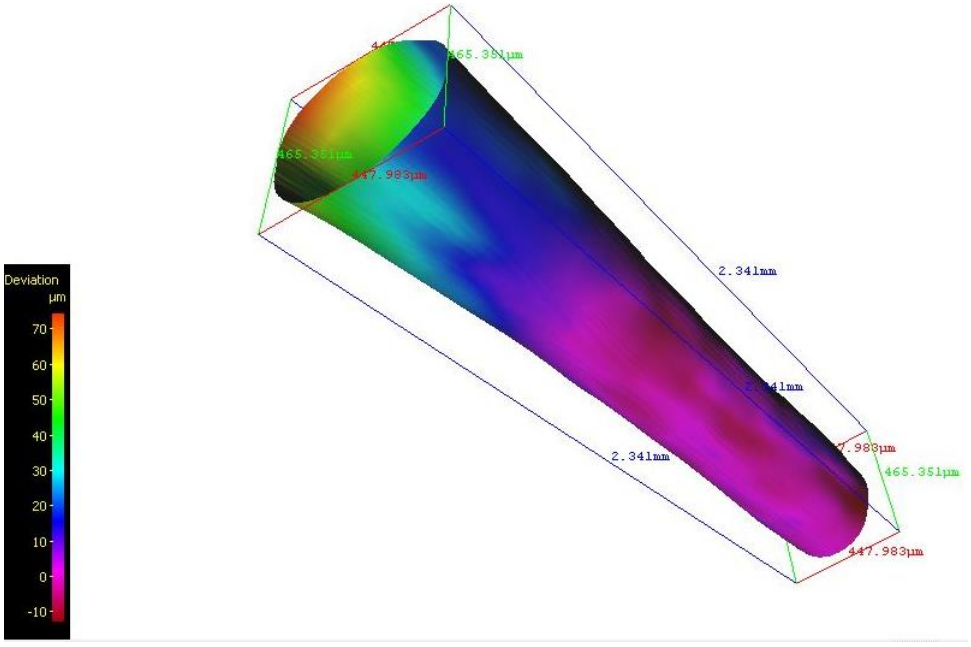
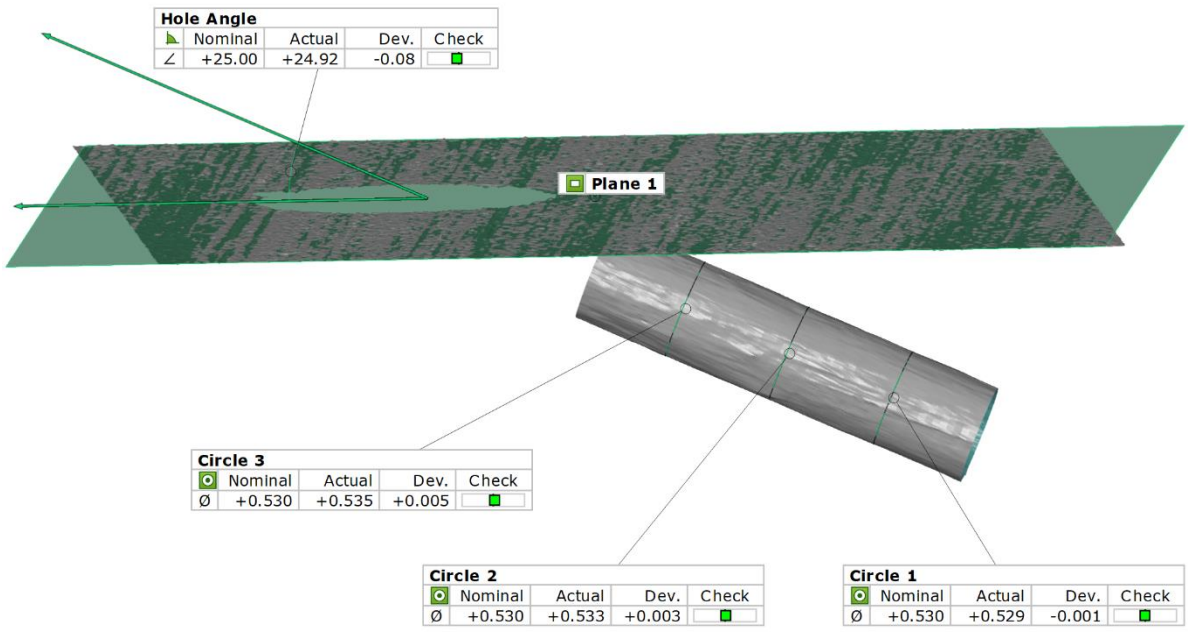


Figure 6

Using this dataset, the built-in analysis software carries out geometric measurements as shown below. This includes entry angle and diameters at various positions along the hole.



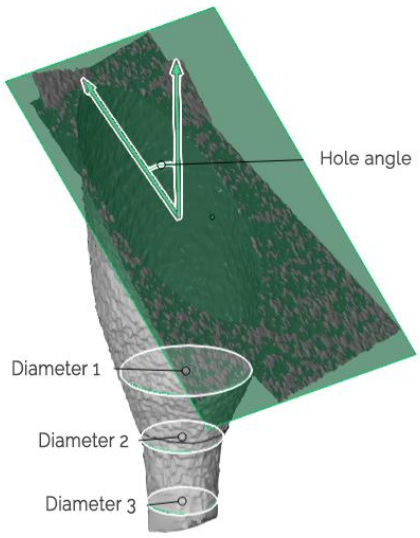


Figure 7

Due to the high accuracy of the Bruker Alicona µCMM of 0.8+L/600 it is possible to measure multiple holes without connection and relate their positions to one another. For example, position tolerance can be determined.

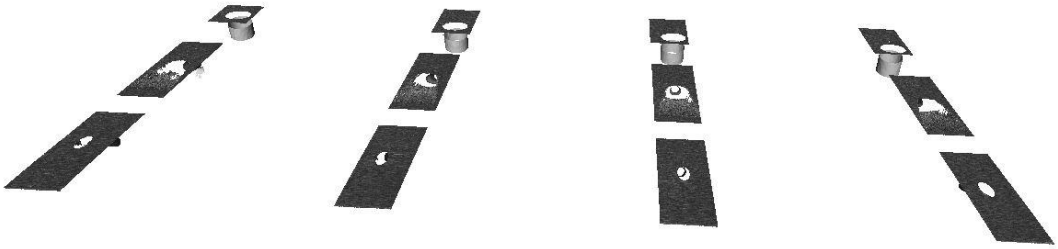


Figure 8

Full automation is possible with *MetMaX* automation software. When the CAD dataset for a component, for example a turbine blade, is uploaded, operators can use a simple mouse click to select which GD&T, Cooling Hole or PMI (Product Manufacturing Information) parameters to measure. *MetMaX* then automatically configures the ideal measurement strategy for an optimized 3D measurement of the part. *MetMaX* software autonomously calculates probing directions, tilt, rotation angles and travel directions in XYZ. Before measurement starts, a virtual simulation ensures a collision-free measurement sequence.

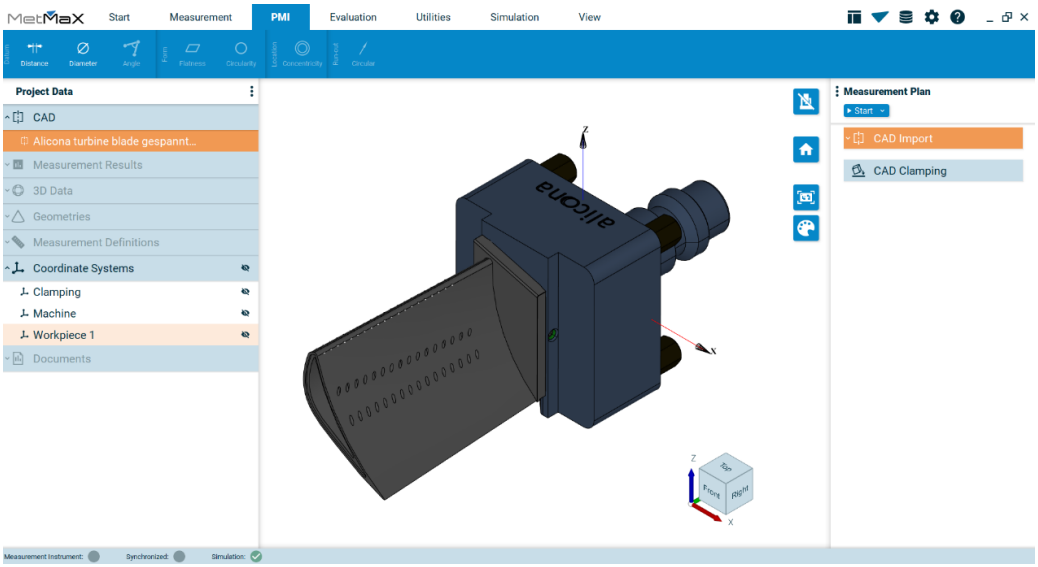


Figure 9

Summary:

It is clear from this report that Optical Metrology using Focus Variation with Vertical Focus Probing can easily and accurately measure cooling holes of various sizes and geometries. Using this technology on the µCMM multiple features can be measured and set into relation for the evaluation of the required parameters. *MetMaX* gives the capabilities from “How do I measure?” to “What do I measure?”. Thanks to this evolution, users do not need any specific metrology knowledge to perform robust measurements.