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Driving Down Inspection Time for Critical Aviation and Aerospace Components

4D Technology's 4Di InSpec AMS measures dozens of edge break features, chamfers, and radii in minutes rather than days, vastly improving throughput and driving down inspection costs.

In industries such as aircraft engines automotive, companies need to rapidly establish the quality of components, both during production and during repair and overhaul. Many of these components are highly valuable and complex, often with hundreds of features requiring inspection.

To date, much of this inspection has been completed manually—a slow and subjective process. A new, automated system is now being adopted for rapid, repeatable, non-contact measurement of features and defects on precision machined parts. Combining the flexibility of an industry-proven optical gage and robotic automation, the system dramatically improves inspection throughput and reliability, recording quantitative data that can be tracked throughout the component's lifetime.



Figure 1. An inspector reviewing pass-fail results from an automated measurement system.

The Challenges of Manual Measurement

In the aerospace and automotive industries, most inspection is done by eye, or with the aid of an optical comparator. Manual inspection, however, is slow and subjective. Hundreds of call-outs can take hours to measure, a labor-intensive process. Many measurement locations cannot be seen or reached, requiring inspectors to create replicas of the feature that can then be measured—an even more time-consuming process.

For some features, inspectors can use stylus-based measurement systems, particularly for edge break on accessible features. A stylus, however, only provides a single trace of data across the feature and is virtually impossible to use on large parts. Any variation in the measurement position or the angle of the instrument with respect to the feature will greatly affect the accuracy and repeatability of the result. Stylus defect measurements are highly dependent on measurement position as well, with slight variation in position leading to very different results. Even with the greatest care, a single stylus trace will only rarely cross the deepest or widest portion of the defect. In addition, styli can potentially damage and scratch the part to be measured.

Improved Inspection with Portable, 3D Optical Gages

Optical gages provide non-contact, 3D measurement of features and defects from 2.0 μ m to 9mm in height. The first such surface gages, the 4D InSpec and 4D InSpec XL, have been widely adopted for handheld, shop floor measurement over the last ten years. These highly portable gages align, focus, and measure in < 1 second—hundreds of times faster than manual inspection. Automatic feature finding calculates statistics on all features and defects in the field of view. Because the gages acquire 3D data, the system corrects for any measurement tilt or alignment error, providing far more repeatable results than other methods.

Applications for optical gages include production, repair-rework, and field measurement. The gages readily measure features such as edge break, radii, and chamfers, and defects such as bumps, dings, nicks, and pits, even in hidden and difficult-to-reach locations.

By accurately assessing features and defects, the 4D InSpec provides much more precise part disposition than visual inspection. Dramatic reductions in scrap and rework have led to 20-40% improvements in yield.



Figure 2. A 4D InSpec optical gage measuring feature depth on a complex geometry.

Automating Feature and Defect Inspection

Aircraft and aerospace engine components may have dozens of critical specifications for chamfers, edge break, and rounding, to prevent crack propagation or to produce tight fit and seal. These numerous features are time-consuming to measure manually. Difficult to access areas must be replicated in order to measure, which further increases cycle time.

Complex parts with dozens or hundreds of callouts, however, require even higher throughput to meet production and repair/overhaul goals.

Developed in conjunction with leading aerospace and aviation engine manufacturers, the 4Di InSpec automated metrology system (AMS) combines a 4D InSpec sensor with a collaborative robot to dramatically improve throughput. For a complex part with more than 50 measurement callouts, the 4Di InSpec AMS can reduce measurement cycle time to less than 10 minutes from upwards of 12 hours using manual inspection.

4Di InSpec AMS Benefits

- Reduced scrap and rework
- Reduced measurement cycle time
- Improved labor utilization
- Improved quality
- Accelerated delivery

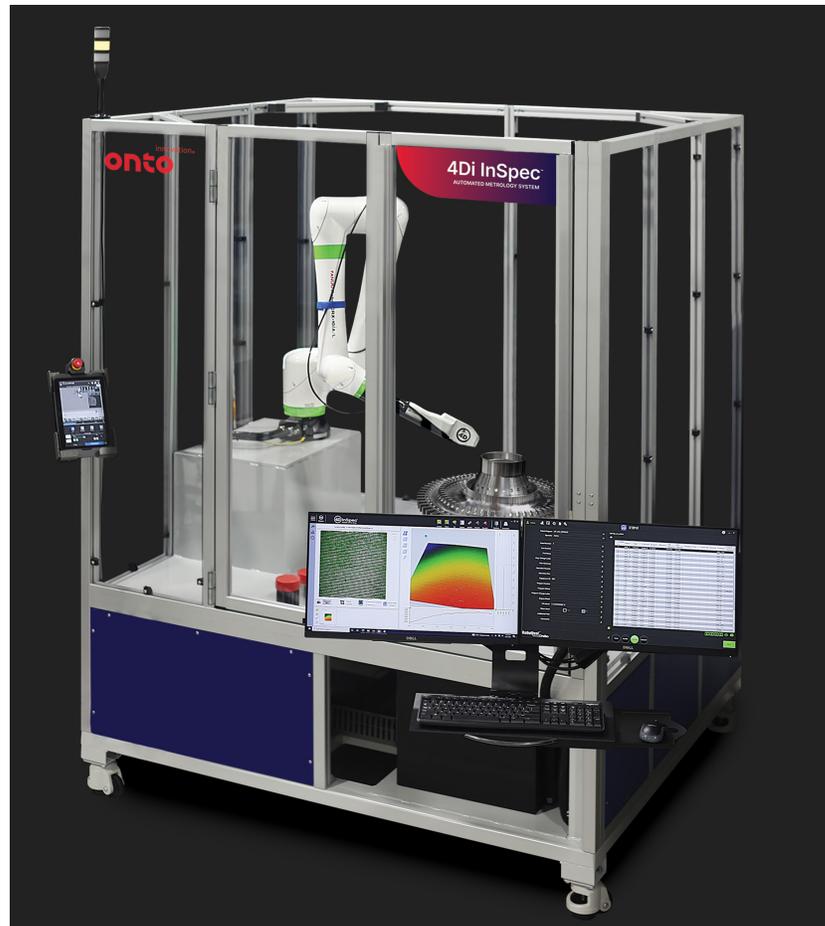


Figure 3. Automated 4Di InSpec AMS cell configuration.

The automated cell affords a number of benefits:

- Dramatically increasing throughput
- inline production measurement
- easy handling of large, complex components that are challenging to manipulate manually
- improved part disposition, leading to reduced scrap and rework
- improved repeatability.

For larger components, an automated, rotary table can be incorporated for easier handling and access to a greater number of features. Smaller components can be mounted directly to the robot and moved about a stationary 4D InSpec sensor.

Because the 4D InSpec sensor is immune to vibration, it can measure with little settling time between robot movements. This is critical for use in a production line, allowing the robot to move the sensor in concert with the manufacturing line without interrupting continuous production.

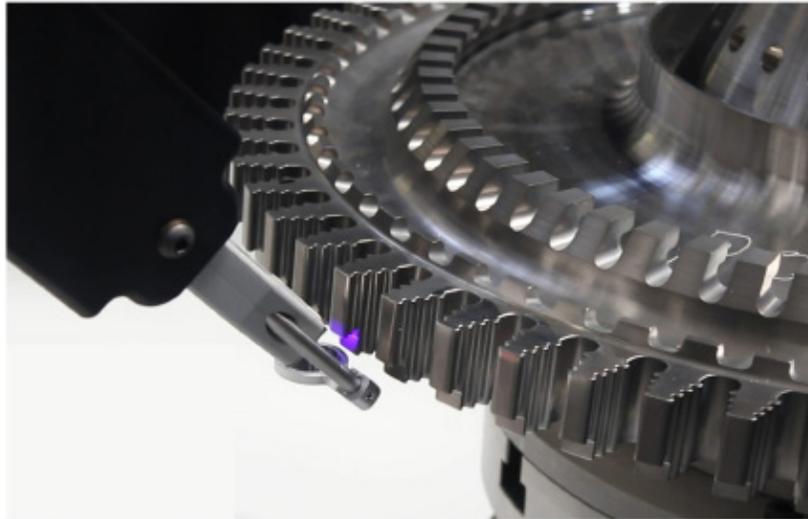


Figure 4. Measure in challenging locations: between fir tree roots and inside of a bore.

Purpose-Built Automation Software

Onboard software automatically acquires and analyzes data. It includes the ability to automatically remeasure at failed locations. This feature improves throughput and ensures that only truly out-of-spec features are flagged for further consideration.

The system's fully-enclosed Fanuc robot and rotary table enable extremely rapid, repetitive measurements. Numerous safety features and a Software Automation Package enables safe, reliable, flexible operation.

Traceable, 3D Data

One of the major shortcomings of visual inspection is that it does not produce quantifiable data that can be tracked over time. The inspector's interpretation of feature sizes, or the severity of defects, is the inspection record.

The 4Di InSpec AMS provides 3D information for each feature. An inspector can immediately see an image of the feature and a range of statistics that can be written to a local database and/or transferred to an SPC system for further monitoring.

The 4Di InSpec AMS acquires greater detail of a larger number of features. This data can be tracked throughout production and across the life of the component, ensuring quality at every stage. Data can be exported to SPC systems or to other software for further analysis.

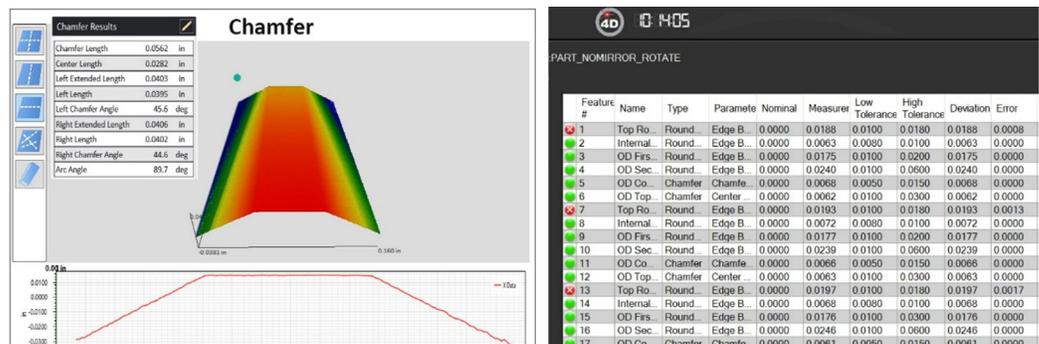


Figure 5. 3D chamfer measurement data and pass/fail measurement results.

Maximizing Process Yield and Quality

The 4Di InSpec AMS accurately captures complex feature dimensions, enabling more precise part disposition. Rapid measurement reduces inspection queuing times, while the ability to measure at more locations in the same time frame ensures part quality.

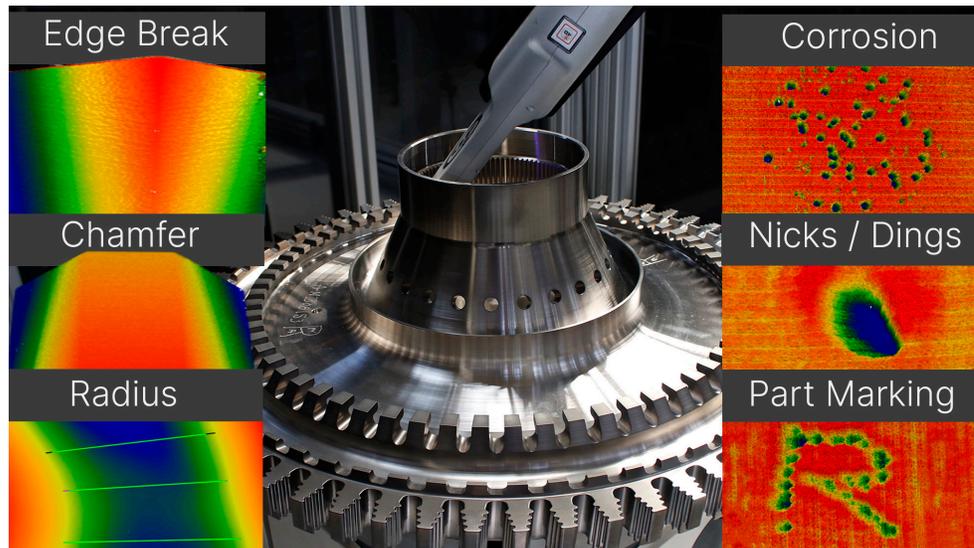


Figure 6. Automated inspection makes it possible to quickly measure hundreds of features and defects per part.

Return on Investment

The return on investment for the automated system is primarily calculated by considering:

- **Reduced scrap and rework.** More accurate assessment of features and defects improves part disposition. Customers have reported 20-40% reduction in scrap and rework due to improved inspection accuracy.
- **Reduced measurement cycle time.** One operator can complete many dozens of measurements in a matter of minutes versus multiple operators spending hours to complete the same process. One customer reported that 44 edge break and chamfer measurements were completed in under 2 minutes with the 4Di InSpec AMS—a process that had required more than 44 hours to complete manually using replication.
- **Higher throughput.** Because of the reduced measurement time per part, an operation may choose to increase their target parts to be inspected per day or week.
- **Improved labor utilization.** Employees freed from replication and other time-consuming inspection operations can now participate in value-adding operations.
- **Improved quality.** Micrometer-level resolution, vibration-immune measurements, and precision positioning result in accurate, repeatable measurements. Reduced measurement time means more locations can be measured on a component, improving inspection reliability and part quality.
- **Accelerated delivery.** Eliminating measurement and queue times, and reducing rework, results in less time in process and quicker delivery to the customer.

In a recent analysis, the combined effects of these improvements resulted in payback for an automated 4Di InSpec AMS of only two months.

SUMMARY

Optical gages such as the 4D InSpec increase throughput of individual surface feature and defect measurements. The addition of automation increases throughput for hundreds of measurements per part. Edge break, chamfers, radii, and surface defects on components can be measured in minutes rather than hours. The accuracy of the metrology is not compromised to achieve this speed. New applications can be accomplished more easily with automation, such as stitching, CAD comparison, and data meshing.

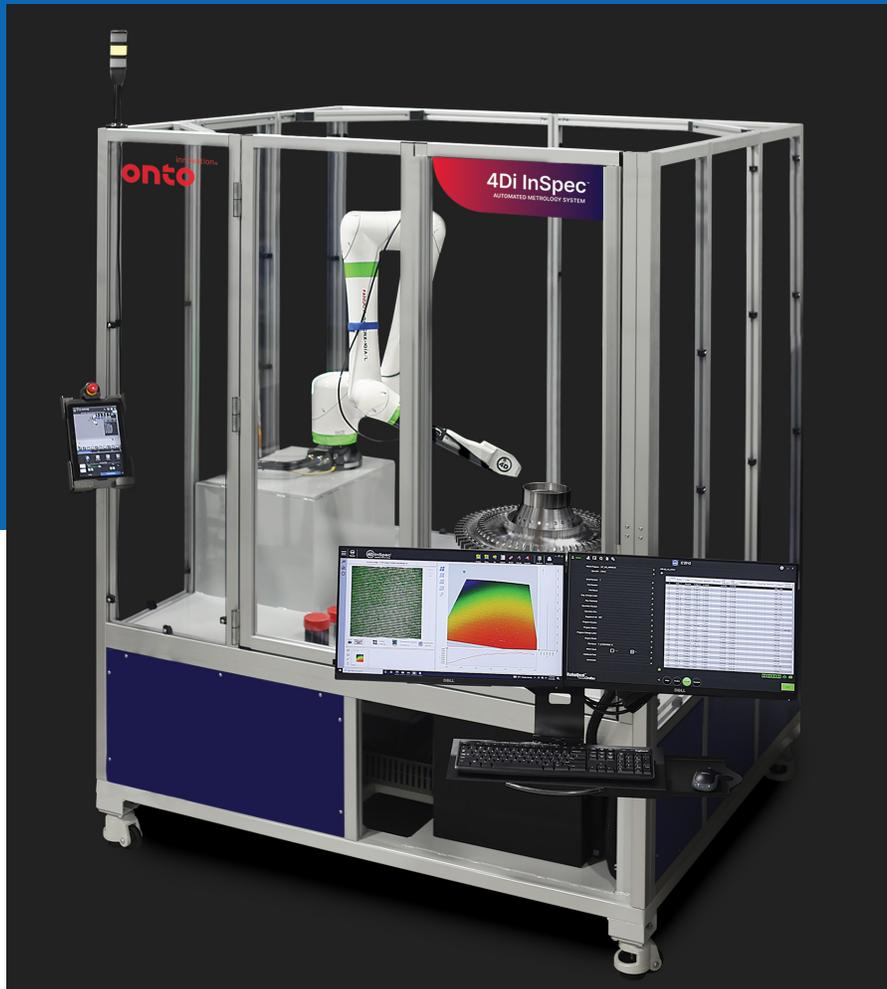
For any questions on the application note or interferometry in general, please contact the 4D application team at 520-294-5600 or at www.4DTechnology.com.

4D InSpec supports engine models from all major OEMs including:

- Pratt & Whitney
- CFM International
- General Electric
- Rolls-Royce
- Safran
- International Aero Engines AG
- and others.

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High-Throughput Surface Defect and Feature Inspection



The **4Di InSpec AMS** is a high-throughput, high resolution defect and feature inspection solution. The automated system can measure dozens of edge break features, chamfers, and radii in minutes rather than days, vastly improving throughput and driving down inspection costs.

Learn more at

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