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Gage-Capable Feature and Defect Measurement with a 4D InSpec® Surface Gage

The 4D InSpec is highly repeatable for measuring surface features and defects on precision surfaces

Introduction

"Gage capability" is a system's ability to provide reproducible data over time, under changing conditions, and with different operators. The 4D InSpec is gage-capable for measuring defects such as nicks, scratches, and pits, and fine-scale features such as edge break, chamfer, and rivet depth. In this article we discuss how the 4D InSpec provides more repeatable data than other commonly-used inspection methods.

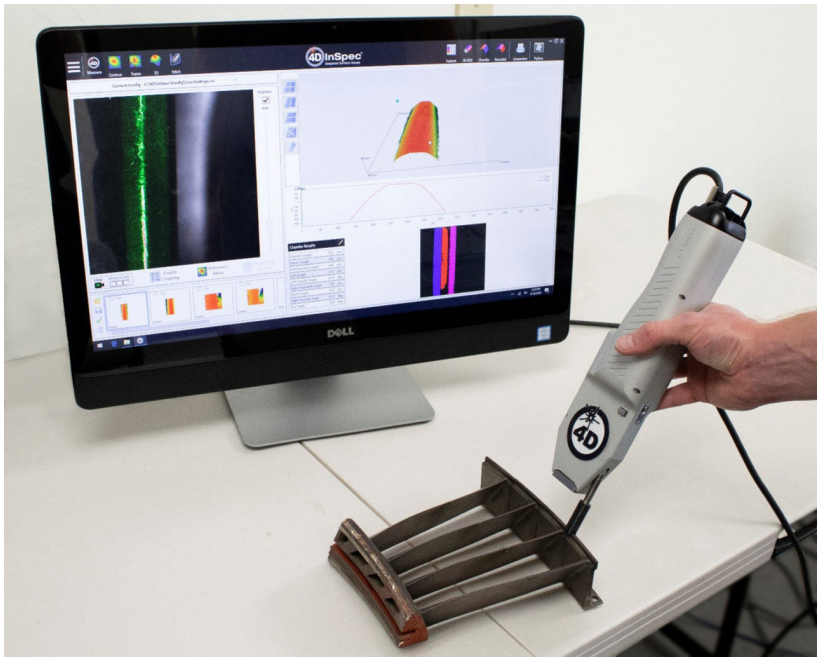

Figure 1. The 4D InSpec provides accurate measurements even on curved surfaces, despite the measurement angle or ambient lighting conditions.

The challenges of visual inspection

Defect inspection on precision parts has traditionally been a highly manual process, relying on either visual review or comparison to a tactile gage or sample coupon.

Inspectors, of course, strive to limit variability and to be as consistent as possible. The reality, unfortunately, is that without the proper instrument an inspector has no way of ensuring accurate, quantitative measurements. With visual inspection, factors such as ambient lighting, ease of access to a feature, and the particular inspector can change the answer significantly. Simply locating the deepest or widest point on a small pit or scratch is extremely difficult to do by eye. An optical comparator can help; however, there is still significant subjectivity involved with aligning the feature on the comparator and with interpreting the results.

2D Stylus measurements

Measurement systems such as stylus profilers or laser line profilers can provide quantitative measurement values and, potentially, a higher degree of accuracy than visual inspection. However, a single two-dimensional trace across a surface is unlikely to cross the absolute deepest or widest part of a feature. Moreover, it is nearly impossible to follow the exact same trace even twice with a stylus—each measurement will be a unique profile across the defect. For these reasons, high repeatability is difficult to achieve with a stylus instrument.

Cosine error becomes a factor as well for chamfer and radius measurements. When lengths are measured with a two-dimensional system, accuracy and repeatability are tied directly to the repeatability of measurement alignment. If, for example, a chamfer face is measured with a stylus, the trace must be taken perpendicular to the edge. Any deviation from this angle will result in the chamfer face being measured artificially long (Figure 2). Alignment is very difficult to repeat and reproduce between different appraisers. Special care must be taken to align the measurement, which becomes very time-consuming.

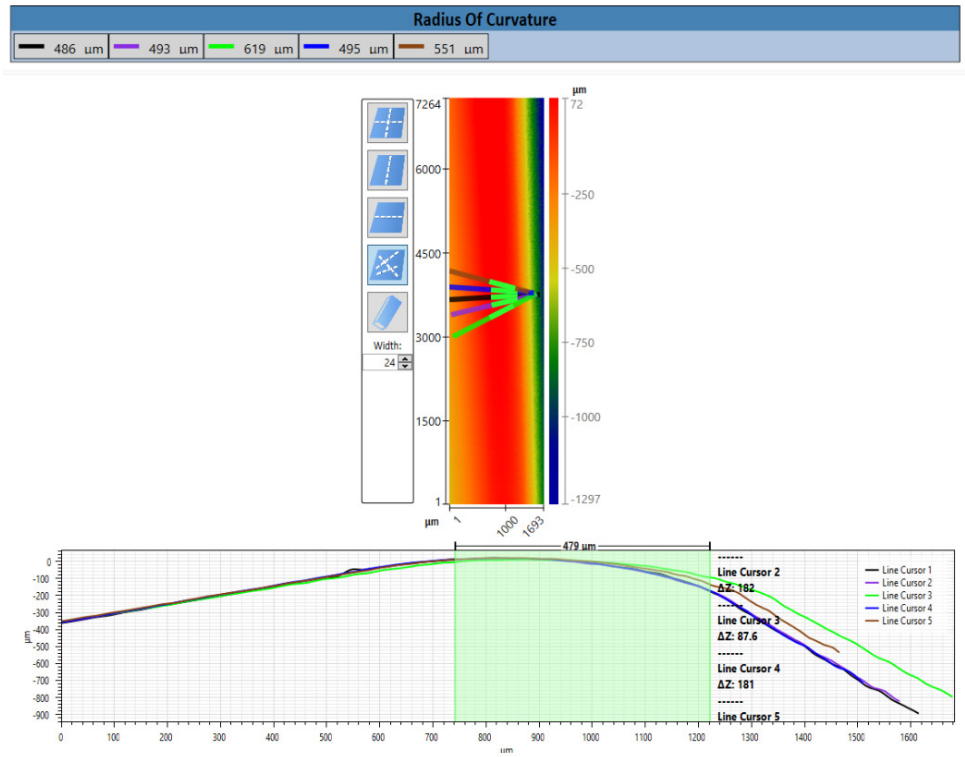

Figure 2. Measurements of a radius vary widely depending on the measurement angle and location, resulting in low repeatability.

Why the 4D InSpec is more consistent

The 4D InSpec measures defects and features in 3D, capturing a large area of the part under test instead of just a single trace across it. Its large field of view ensures

that the deepest and widest portion of a feature is always imaged. Advanced feature-finding software consistently returns results with micron-level accuracy for depth, width, volume, radius of curvature, etc.

The instrument's patented optical design makes it possible to confidently measure despite environmental vibration and variability in measurement angle, ambient lighting conditions, and part reflectivity. Portable and hand-held, the gage provides one-button measurement anywhere on the shop floor.

Measurements with the 4D InSpec take just a few seconds each to acquire and analyze the data. 3D measurements can be taken on almost any surface. Using the 3D data, alignment errors are mathematically removed, ensuring quick and repeatable measurements. The instrument's speed, portability, accuracy, and repeatability make it an unmatched method for measuring small features quickly, throughout a production or repair facility.

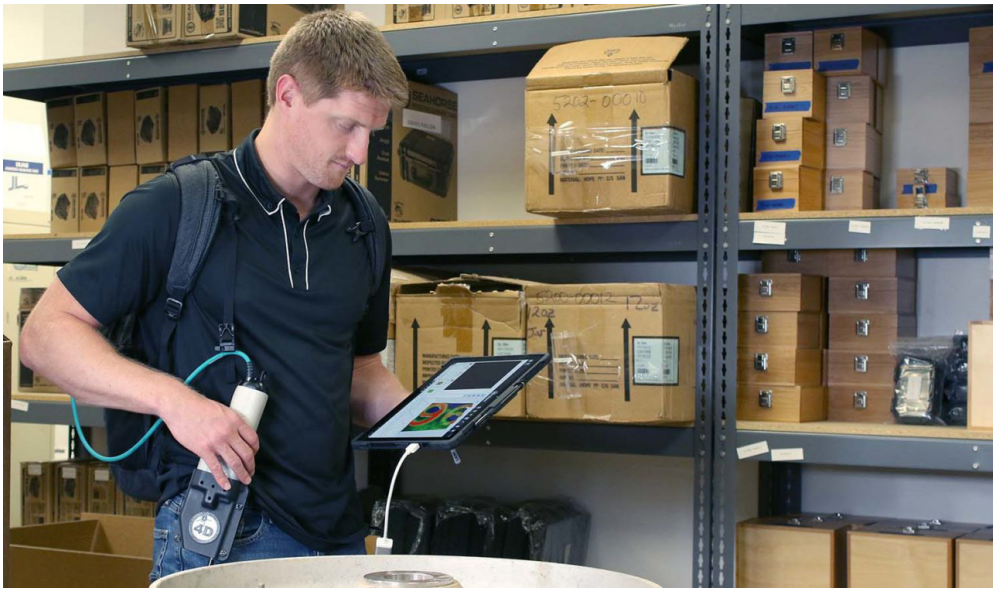

Figure 3. An inspector can use a 4D InSpec throughout the facility. Measure large components in place, and measure despite ambient lighting conditions, reflectivity, or other challenges for visual inspection.

What does a Gage Study show?

A Gage Repeatability and Reproducibility (Gage R&R) study is used to quantify the variation in measurement data that is due to the measurement system, and to identify the sources of that variability. In this type of study multiple appraisers measure features on a series of parts, several times each, and the overall degree of variability is calculated.

A good measurement system will exhibit very low noise such that most of the measurement variance comes from the actual differences between the measured parts. The 4D InSpec has been found to be gage capable on a wide variety of defects and features, on a range of materials. This includes scratches, nicks, dents, edge break, chamfer, countersinks, edge transitions, and steps such as rivets.

The two studies below give a good indication of the types of measurements that can be made and how well the instrument performs. In both studies, the Analysis of

Variance (ANOVA) Method[1] was used to calculate the results. Unlike the Average and Range method, the ANOVA method can distinguish the relationship between the appraisers and the parts.

Edge Break Gage Study

"Edge break" refers to chamfers, angles, and radii applied to sharp, machined edges to improve performance and reduce injuries. Adding radii and chamfers limits possible fracture points on components that are subject to high stresses or loads.

For this study, three appraisers measured ten chamfers on an edge break standard (Figure 4). The chamfer lengths ranged from 0.005" to 0.040", and each appraiser measured the chamfers three times each with the handheld 4D InSpec.

The results of the measurements are charted in Figure 5. Note that the variability is so slight that the nine measurements at each location (three appraisers, three measurements each) are almost exactly superimposed. The GR&R 6σ variation for this study was found to be 0.0009", with just 0.89% of the variation in the study originating from the 4D InSpec or the measurement process. This impressive result indicates that the 4D InSpec provides reliable, repeatable results over a broad range of chamfer lengths.

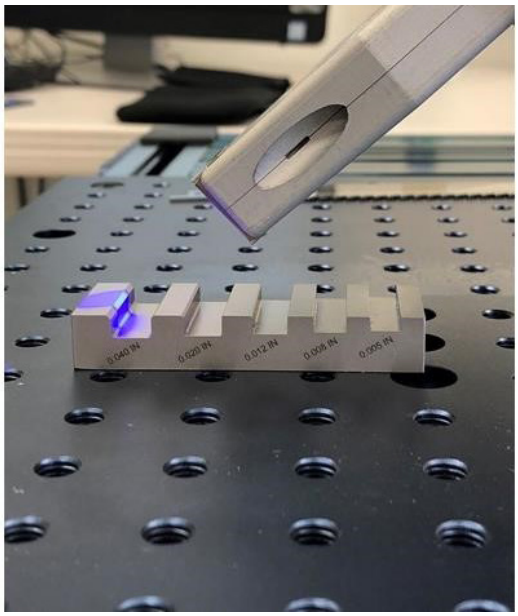

Figure 4. Measuring chamfers on an edge break standard with the 4D InSpec.

1 https://www.spcforexcel.com/knowledge/measurement-systems-analysis/three-methods-analyze-gage-rr-studies

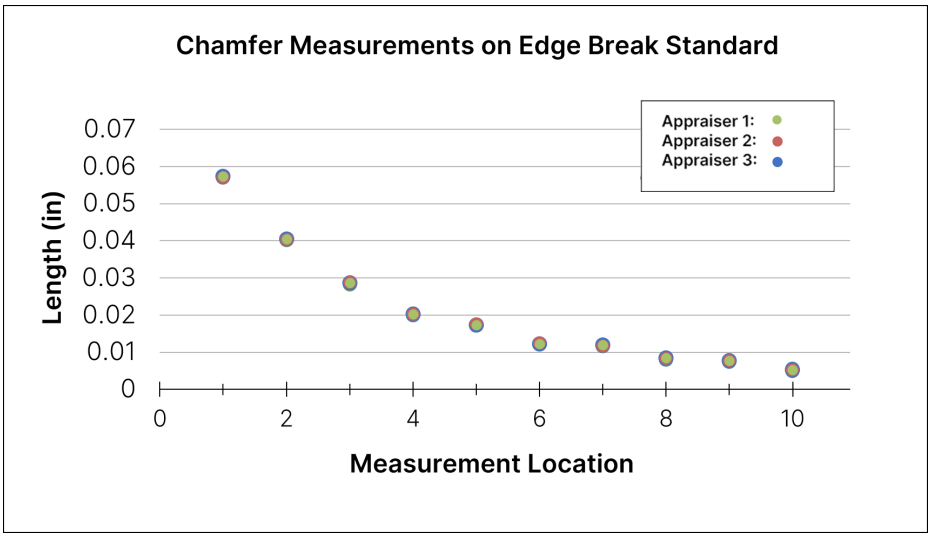

Figure 5. Three appraisers measured 10 locations on the edge break standard, three times each. The results precisely overlap, indicating that the process is highly repeatable.

Gage Study on Defect Comparator Plate

A comparator plate contains a range of features and/or defects of known size that can be visually compared to part defects in a production or repair-rework environment (Figure 6).

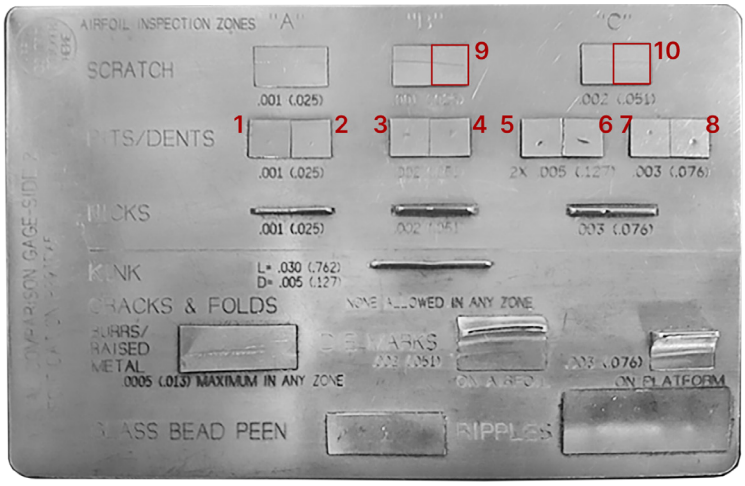

Figure 6. Defect comparator plate. The 10 measured areas are noted in red.

In this study, features on a comparator plate were used to demonstrate the repeatability of the 4D InSpec for measuring a variety of defects. The plate contained scratches, nicks and dents ranging in depth from 0.001” to 0.006” (25–150 µm). As in the edge break study, three appraisers measured 10 areas of the plate, three times at each location. The study was completed twice: once with the instrument handheld, and once mounted in its workstand.

In the handheld application, the GR&R 6σ variation for the study was 0.00074” (18.8µm). When mounted in the workstand the repeatability improved even

further to 0.00048" (12.2µm).

Figure 7 shows the measurements made at each location. Again, the measurements overlap very precisely, indicating that the 4D InSpec is gage capable for measuring irregular defects as well as more regularly-shaped features.

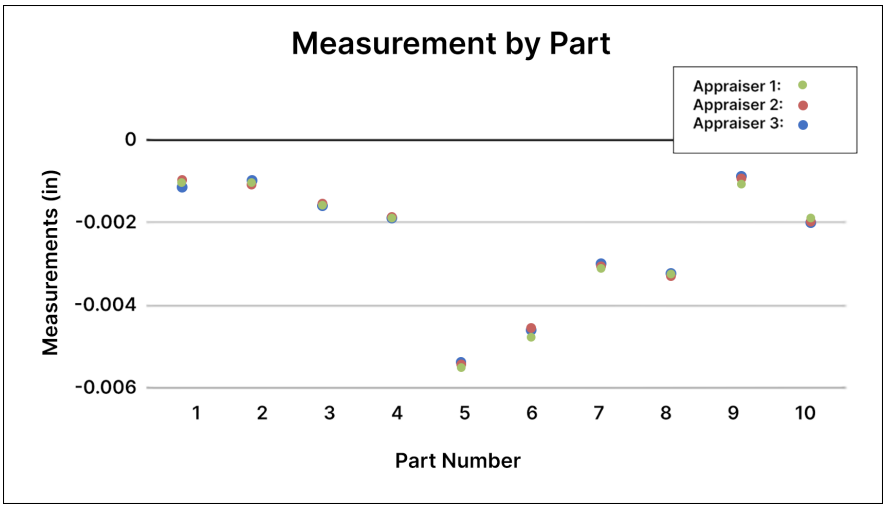

Figure 7. Three measurements by three operators, at each of the ten comparator plate locations

Conclusion

Accurate, repeatable process control measurements are critical to any quality control program. Gage-capable measurement systems provide inspectors with the tools they need to reliably measure and track key process parameters. The 4D InSpec has proven to be gage-capable in a wide range of measurements of surface features and surface defects. Portable, rugged, and reliable, the 4D InSpec is a production-ready instrument for measuring precision surfaces throughout a factory or repair/rebuild facility.

Gage-capable feature and defect measurement

Download the data sheet:

Check out the 4D InSpec gauge today

The 4D InSpec provides, highly repeatable, highly portable measurement of features and defects, with easy alignment and one-button measurement. Inspectors can measure more edge locations faster and with better repeatability than visual inspection—anywhere on the shop floor. Measure edge breaks, chamfer angles, radius of curvature, and rivet depth, as well as burrs, peen marks, corrosion, wear, scratches, roundoff, and more, or metals, composites and plastics.

Quantify your results for repeatable inspections and increased yield. Find out more today.

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