Testing Measurement Accuracy of Ground Diameters

Justin St. James
Six Sigma Concepts, LLC

Intro

Despite over a century of technological advances, physical gage blocks and pins are still used as the gold standard in accuracy. Although a precision ground pin may not be the part that a user ends up inspecting, it provides a reliable gauge to evaluate an inspection device's performance. A sample commercial part with a ground diameter is used to validate the systems performance with a more representative sample of potential user parts.

Diameter Measurement of Ground Surface			
Live Measurement		Average Measurement	
Tolerance	GR&R	Tolerance	GR&R
±0.00003	<30	±0.00002	<30
±0.0001	<10	±0.00006	<10
±0.001	<1	±0.0006	<1

Measurement Conditions

The InGage Discovery with a 1.2" x 1" field of view and a 1.3MP resolution imager was used for these tests. Each pixel in the image roughly translates to a 0.001" x 0.001" area. Thirty-two (32) inspections were taken for each measurement. Each live measurement is taken from a single image with no averaging. Each average measurement is the average value derived from ten (10) consecutive images over one (1) second. Tests were taken in an office environment. The sample gage pin used was a 0.5" Class X Go Gage pin. The pin's diameter is toleranced between 0.50000" and 0.49996" a total of 40 millionths. One measurement of the diameter is with an InGage software Vernier tool across a 1" length of the pin, while the other has a Vernier tool across a 0.0625" length. The different Vernier tool lengths are used to find the effect that sampling size has on measurement noise.

System Noise

The absolute limit of the system's accuracy is the system noise. To measure the system accuracy, the gage pin is measured while stationary.

Measurement	**Across 1"**	**Across 0.0625"**
Live | Mean Value	0.499999	0.499995
Live | Standard Deviation	1.8 Millionths	2.2 Millionths
Average | Mean Value	0.499992	0.499999
Average | Standard Deviation	0.8 Millionths	1.1 Millionths

Calibration and System Noise

The best test of the system's accuracy is to measure the total calibration and system noise. To do this the gage pin is moved, but not rotated, between each measurement.

Measurement	Across 1"	Across 0.0625"
Live | Mean Value	0. 499994	0.499999
Live | Standard Deviation	2.7 Millionths	4.0 Millionths
Average | Mean Value	0.499992	0.499995
Average | Standard Deviation	1.3 Millionths	2.2 Millionths

Verification: Calibration and System Noise with Commercial Ground Pin

To verify that the results are not unique to precision gage pins, a commercial part with a ground diameter is also tested. This commercial part is moved, but not rotated, between each measurement. The accuracy matches the results achieved with the gage pin.

Measurement	Across 1"	Across 0.0625"
Live | Mean Value	0.312452	0.312461
Live | Standard Deviation	1.9 Millionths	4.9 Millionths
Average | Mean Value	0.312452	0.312463
Average | Standard Deviation	1.1 Millionths	3.6 Millionths

Results

Given the correct conditions, backlit profile measurements can achieve extremely accurate results in little to no time. The main reason that a ground pin was sampled is that it has established dimensions, without which, measurements at the accuracy we are achieving would be unverifiable. Based on these results we can help define the accuracy that the InGage Discovery and backlit profile metrology can achieve. Our subpixel accuracy is achieved through an algorithm that analyzes the edge of the part profile. Additionally, while sample size area can affect a measurement's standard deviation, measurements over a smaller sample area can still achieve high precision.

While these results may not represent all parts and all measurements, it is critical to establish baseline performance. Once established, claims about system accuracy can be defined beyond a blanket claim with an arbitrary number. Additionally, without establishing a baseline, there would be nothing to compare to when gauging performance while measuring other part surfaces and features.