Comparison between OG™ 2000 and Interferometry-based Flatness Devices

SUMMARY

The OG™ System has gone through a study to compare with an interferometry-based flatness device. There exist evidences that the OG™ System correlates with the interferometry-based device very well on flat parts. However, the interferometry-based device failed to detect an artificial recess on a part with surface discontinuity while the OG™ System demonstrated its ability of measuring the entire surface.

INTRODUCTION

Flatness is one of the important geometric tolerances often specified in many engineering designs that require flat surfaces. Instruments used to measure flatness have evolved for decades. One of the early instruments utilizes a precise potentiometer, driven by gravity to measure "slopes" along the grid webs. The other approach utilizes a dial indicator on a flat granite table in which the table works as a reference. Other instruments like surface profilers are commonly used. These devices have some drawbacks. They are typically time-consuming in data collection. Therefore, either the number of data points is limited or the area measured is restricted.

The arrival of interferometric devices brought flatness measurement into a new era. A surface can be digitized into thousands of points in seconds. The interferometry-based devices provide great accuracy and have been prevailing in industry, automotive, semiconductor, hard disks, etc. The industry started to have a more comprehensive view of flatness given the quantity of data points acquired in a reasonable period of time. However, interferometric devices are NOT the final solution. They have some detrimental failure modes. For instance, a combination of large area and surface discontinuity poses a mission impossible for this kind of devices. Harsh factory floor environment is another killer to the delicacy of an interferometric device.

OG™ 2000, as a system to answer the call for flatness measurement of automotive valve bodies (a combination of large area and complex surfaces, often with surface discontinuity), has evolved to challenge all the flatness measurement devices, including interferometric devices, in resolution, accuracy, and throughput. Furthermore, the OG™ System provides the ruggedness that supercedes all other technologies with the same degree of accuracy.

This technical note is intended to explore the performance similarity and fundamental difference between the OG™ System and the interferometry-based

devices. The information provided in this note is based on a study conducted by OG Technology, with the help from a major US manufacturer. Parts used in the study were measured on both the OG™ 2000 system and a flatness measurement device that is based on grazing-incidence interferometry.

SUMMARY

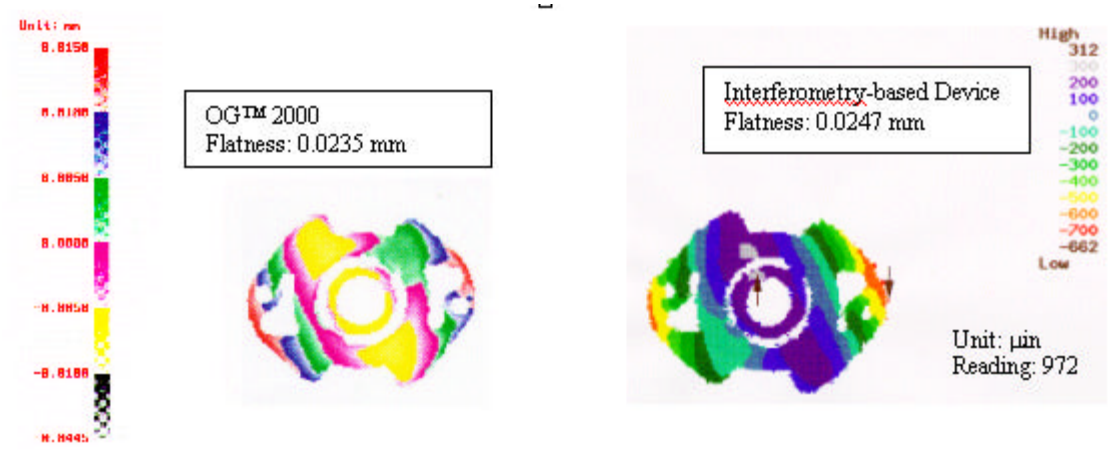
- OG correlates with interferometric devices in flatness measurement;
- OG shows capability in handling surfaces with discontinuity;
- OG shows ruggedness against vibration, temperature, humidity, etc.;
- OG demonstrates high throughput.

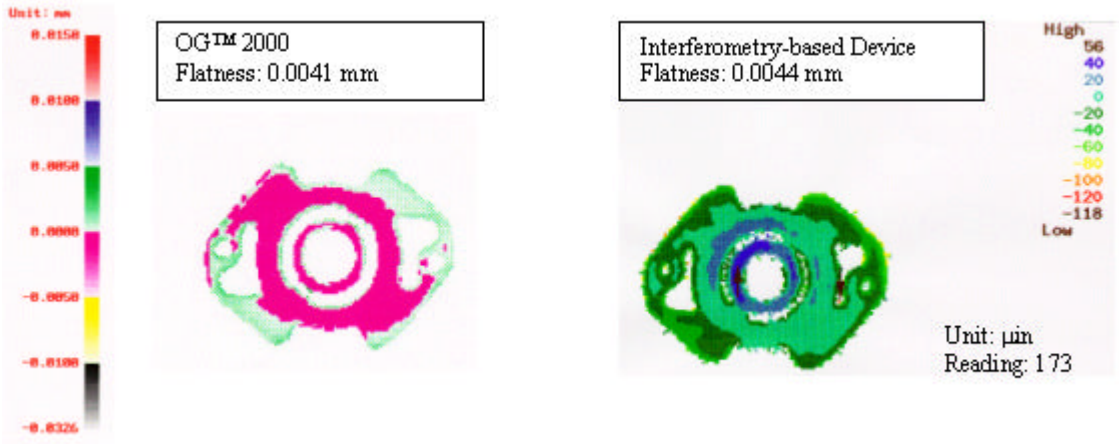
Attribute	**OG™ System**	**Interferometric Device**
Principal Technology	Measure light absorption amount	Count interferometric fringes
Measurement Reference	Absolute	Incremental
Measurement Media	Light and fluid	Light (and air)
Polarity Information	Embedded in the signal	Obtained with moving optics (phase shift)
Motion in Data Acquisition	None	Phase Shifting Optics
Calibration	With every measurement	At set up
Resolution	0.005 microns	0.01~0.1 microns
Accuracy	0.1 micron	0.15 microns
Dynamic Range	2000x of resolution	30~100 microns
Number of Data Points	1,000,000	60,000
Vibration	Insensitive	Sensitive
Temperature	Insensitive	Sensitive
Humidity	Insensitive	Sensitive
Throughput	N parts (in 12"x12") in 30 seconds.	Typically 1 part in 10 seconds.
Factory Floor Ruggedness	Yes	No
Cost	$95,000	$130,000 (?)

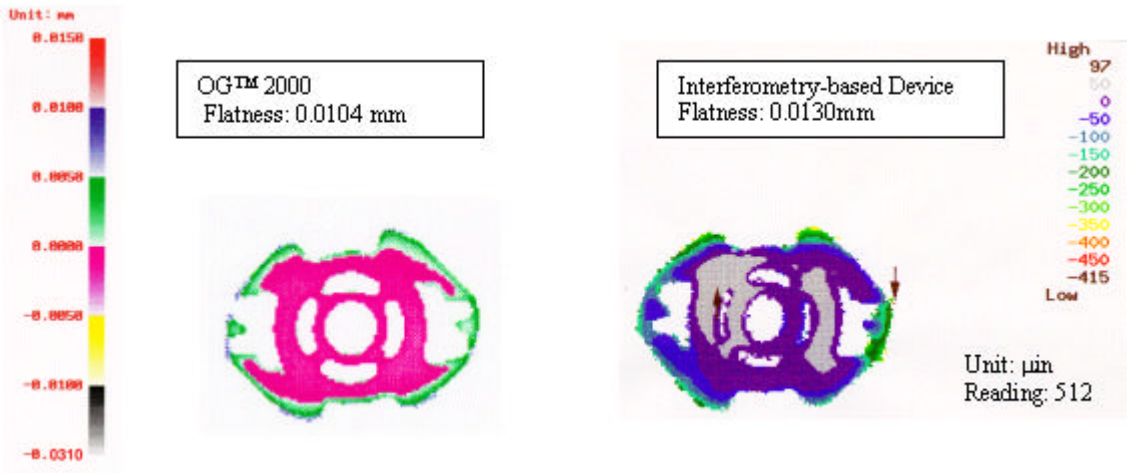
DETAILS

OG™ Correlates with Interferometry-based Devices

We conducted a test with three (3) usual parts that have a flatness allowance of 5 microns on their lapped or ground surfaces. The correlation is obvious in two ways: First, the readings of flatness are close. In one case the difference is as small as 0.3 microns. Secondly, the surface profiles are matching (as illustrated by the color-coded maps).
The following picture pairs illustrate the correlation. The left-hand side pictures are results generated by the OG™ System and the right-hand side pictures are generated by an interferometry-based device.

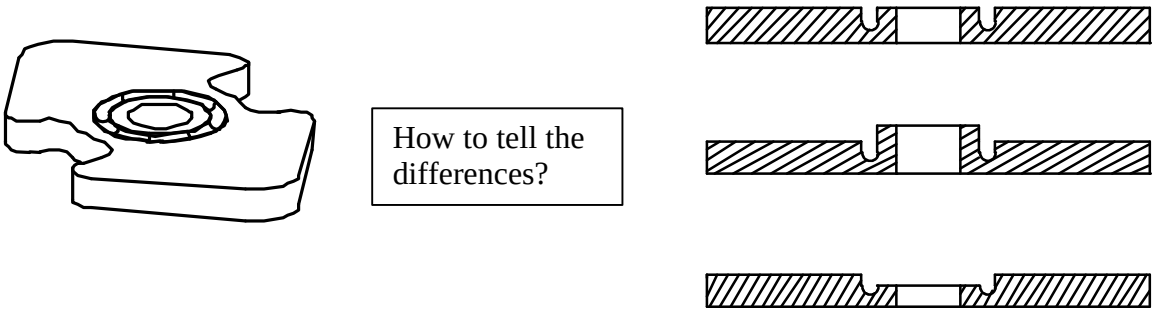






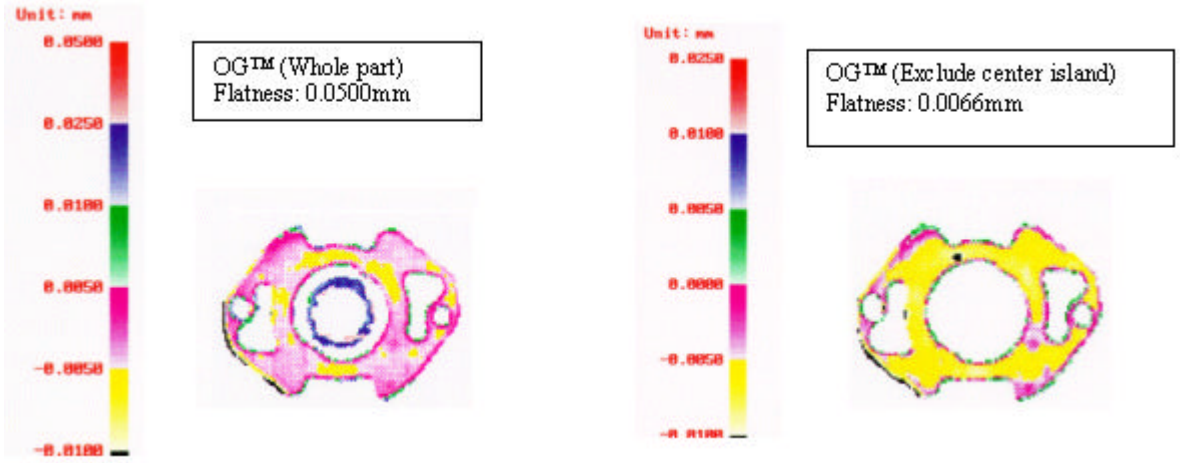
OG shows capability in handling surfaces with discontinuity

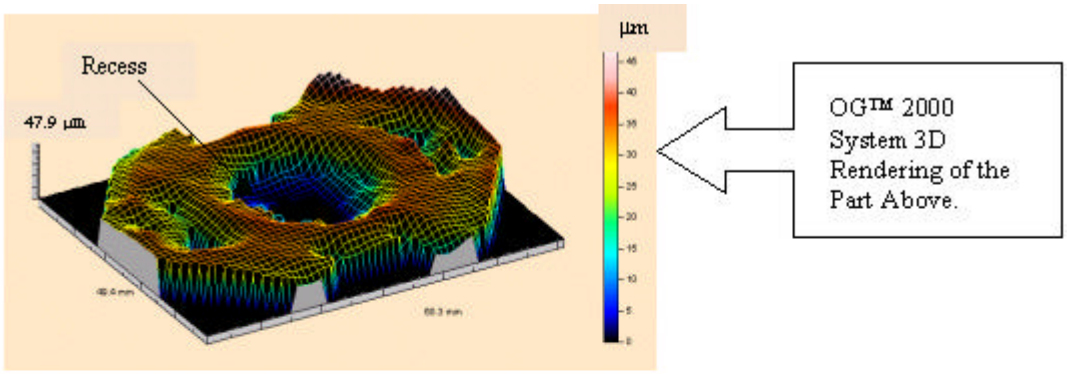
Because interferometric measurements are taken by counting fringes, which is a periodically repeatable pattern (dark-bright-dark-bright-dark-…), the measuremen process is inherently *incremental*. The surface to be measured has to be an integrated surface; otherwise the fringe counting process will lose the datum. That is, interferometric devices are not capable of discerning the following surfaces:

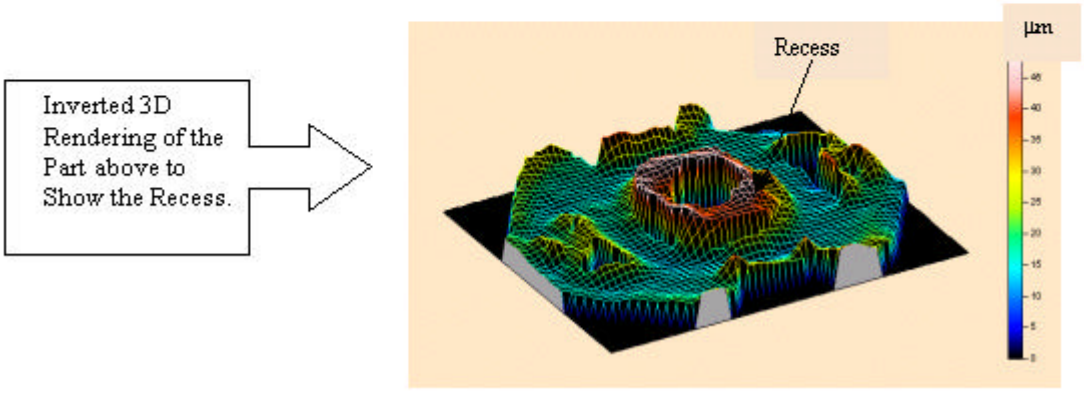


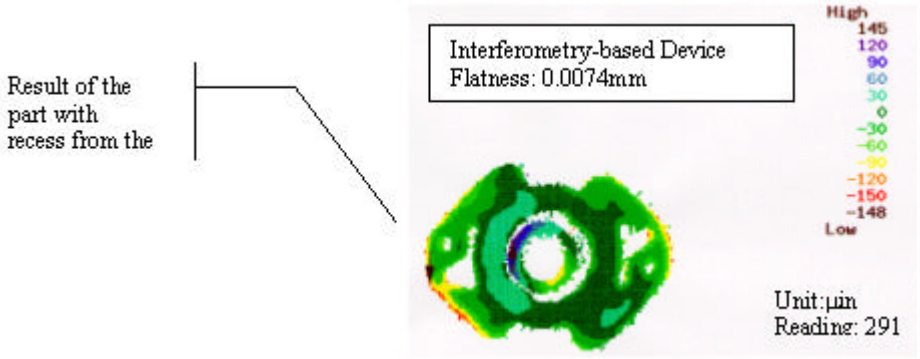
We designed a test with a part that has an isolated ring surface in its center. We made a recess (0.0015" to 0.002", or ~50 microns) at the isolated ring surface and measured the part on both the OG™ System and the interferometric device. The readings, as shown in the table, show that the interferometric device failed to discern the recess (0.0074mm) while OG™ successfully and accurately picked up the recess (0.0500mm). We further verified the measurement of OG™. The center ring was removed from the data set and a best fit is re-done. The flatness reading (0.0066mm) is lower than that generated by the interferometric device (0.0074mm), which correlates closer between the two.

Interferometric Device	OG™ (Whole part)	OG™ (Excl. center island)
0.0074 mm	0.0500 mm	0.0066 mm

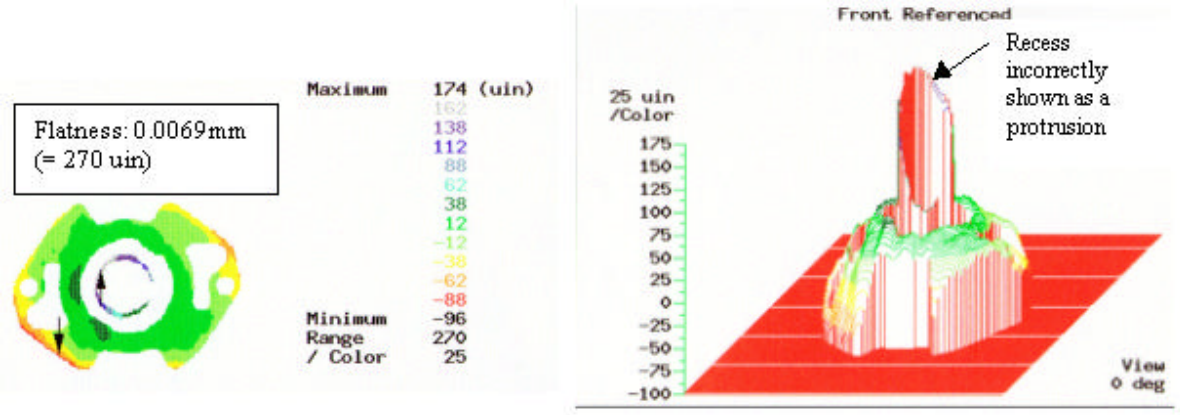








The part with a recess was later measured by another grazing-incidence interferometric device owned by a major automotive part supplier. As shown in the picture (below), the interferometric device did not only fail to detect the recess, but also created its own version of the surface (as a protrusion). Again, the reading (0.0069 mm) is not even close to the amount of recess (missed by 7 folds).



OG shows ruggedness against vibration, temperature, humidity, etc.

Accurate devices, such as interferometric devices, are typically delicate and fragile. They are very sensitive to the environment. It is very difficult to move this kind of devices out of laboratories into factory floors.

In contrast, OG™ has been tested under vibration and temperature variation. During the Gage R&R test conducted by a major US automotive maker, the OG™ System was subjected to shaking, tapping, and heavy floor actions. The reading during the R&R test, nevertheless, showed no evidence of vibration effect. In addition, OG™ does not require a temperature-regulated room for its operation.

Humidity is not a problem because OG™ uses water-based fluid as the measurement medium.

OG demonstrates high throughput

With the use of a high resolution camera and the ability to scale up, OG™ provides a large field of view with better X-Y resolution as compared to the 5"x5" or smaller windows provided by most interferometric devices. The result is that OG™ is capable of measuring multiple parts simultaneously.

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