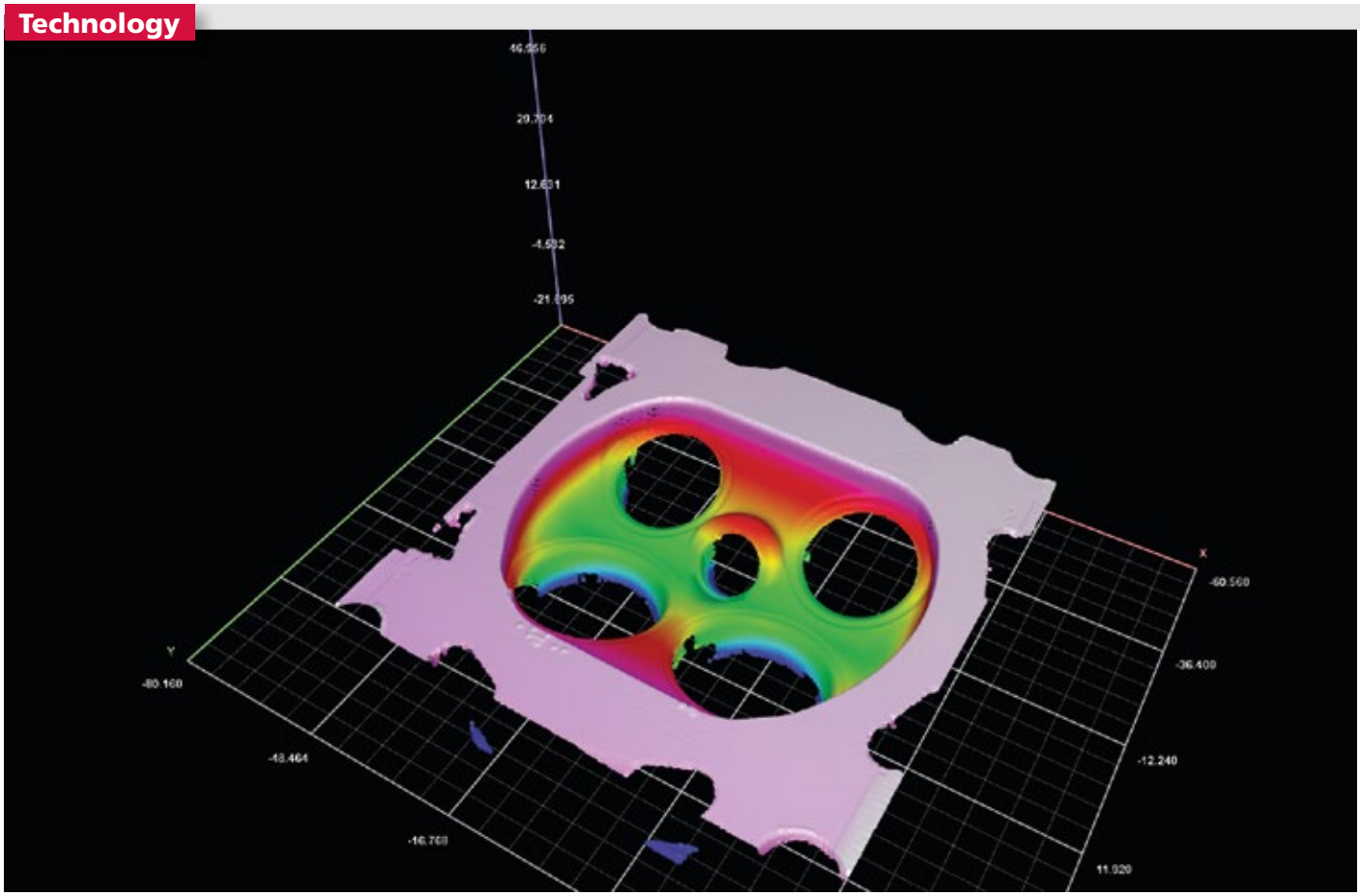


The Volume Checker

Delivering Application-Specific 3D Inspection Solutions through Firmware Customization

A flexible smart sensor platform supports model customization at manufacturing level. This approach allows users to configure standard sensors to serve application-specific requirements for a particular industry.

A development kit called Gocator Development Kit (GDK) is the primary enabler of LMI's application-specific approach to 3D sensor design. Using GDK, developers can embed their own custom measurement algorithms onto a Gocator sensor with the same functionality as built-in native tools – which in turn gives users the ability to perform highly specialized measurement tasks. Custom algorithm development is achieved using Visual Studio in ANSI C, with no need to learn a new IDE/Development Environment or programming language. Users simply develop their measurement tools, build them into a custom binary firmware library, and upload the custom firmware to a Gocator sensor.

Use cases include:

- Applications that require specialized algorithms to process captured data.
- Applications that are upgraded to smart 3D sensors where algorithms are already available in the form of pre-compiled libraries, which can be accessed from within a custom tool running in a hardware accelerator.
- Applications where the users intellectual property (IP) must be protected from exposure to third parties. In this case using a custom sensor tool ensures the IP stays within the company.

The Volume Checker

In specific cases LMI will design a custom measurement tool expressly for the customer and their application. Gocator Volume Checker is an example of the power of this process at work. Leveraging 3D snapshot sensors, the GDK, and several supporting technologies, LMI designed the tool to provide a fully customized 3D solution for high-speed, accurate volume measurement of engine cylinder heads and piston bowls in small to medium-sized internal combustion engines (ICEs). As an automated 3D non-contact solution, the solution effectively replaces manual measurement approaches for automotive tier two and three component suppliers.

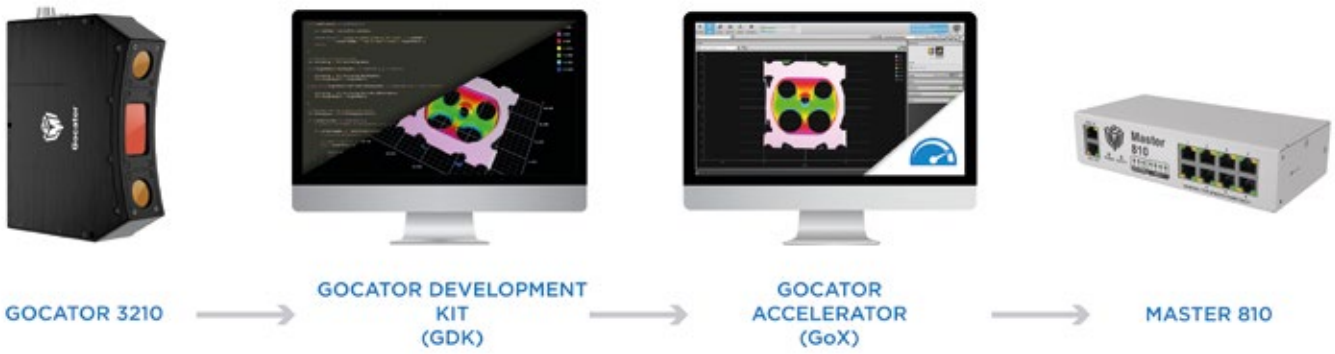
About Engine Volume Gauging

Each cylinder in an engine block has to be measured for correct combustion volume. While CAD data can be used to determine nominal volume, compliance testing requires the acquisition of a large number of measurement points, their connection by line or curve approximation, and finally computation of volume displacement.

Traditional Contact-Based Methods

Tactile coordinate measuring machines (for example CMMs) can accomplish volume gauging with a high degree of accuracy. However, this method can take more than two minutes per chamber, where all chambers need to be measured.

As a result of the slow speed and high cost of CMMs, the vast majority of manufacturers use liquid (a technique known as litering) to measure engine volume. Acoustics and



The complete Gocator Volume Checker solution.

pressurized air are less commonly used contact-based methods. All three of these traditional methods are time-consuming, because there is significant setup time involved and only one cylinder can be measured at a time. Additional time is required for clean up after measurement is completed.

The Advantage of Optical Methods – Structured Light

Optical methods based on structured light (fringe projection) offer a 3D scanning method that is non-contact and area based. 3D

Gocator Volume Checker inspecting engine cylinder heads.

scanning with this method is significantly faster (seconds, not minutes) and produces much higher density 3D data, representing a more accurate shape of the part. Snapshot sensors deliver this type of 3D scanning technology. A structured light 3D snapshot sensor projects a line pattern onto the cylinder head of an engine block. The line pattern is recorded by a camera from an optimal angle, yielding information on the cylinder's surface topology calculated from the deformation of the projected lines. Stripe pattern projection provides coordinate resolution down to 1/50 of the projected stripe width. This means the cylinder head can be fully inspected with the acquisition of just a few dozen images with slightly shifted stripe positions, i.e. phases, which can be accomplished in just a few seconds.

Gocator Volume Checker – The Components of a Custom Solution

Volume Checker is made up of several components, of which GDK is the operative technology in achieving customization.

1. Gocator 3210 Snapshot Sensor – Hardware

Gocator 3210 is the hardware platform of the Volume Checker solution. The 3210 is a metrology-grade, inline ready snapshot sensor that scans at 35 µm resolution, and it is ideal for detecting features on large targets such as automotive cylinders. Features are a fast scan rate (4 Hz full-field), a stereo camera design that minimizes occlusions, a small form factor for easy system integration, and a wide field of view (FOV) up to 154 mm.

2. Gocator Development Kit (GDK)

The GDK allows developers to embed their own custom measurement algorithms into the Gocator firmware with the same functionality as native tools. Custom tools allow users to perform specific measurement tasks. In the case of the Volume Checker, LMI has embedded a custom volume gauging tool that can scan and measure cylinder heads in less than five seconds at an accuracy of +/- 0.04 cm^3.

Application Examples

The benefits of the GDK are not limited to volume checking applications alone. It has been used to successfully create custom solutions for:

- Battery flatness inspection – Custom tool combines multiple scans of the battery surface, corrects for tilt and overlaps, and calculates overall flatness.
- Peak detection in various materials – Custom tool detects all peaks in a profile and outputs the coordinates.
- Height measurement in non-uniform part inspection – Custom tool measures the heights between various positions and outputs measurement value and control decision.

In all of these cases the GDK gives users complete control over how and where their custom measurement tools are used, therefore safeguarding their valuable intellectual property. Plus, custom algorithms are easy to troubleshoot on-site, which allows for rapid response to urgent client issues and reduces integration time with existing systems.

3. Gocator Accelerator (GoX) – Sensor Acceleration

GoX is an important supporting technology in the Volume Checker solution. This PC-based application accelerates the Gocator 3210 sensors by offloading compressed 3D scan data to a PC – for unpacking and analysis – to achieve the fast cycle times required for inline engine block inspection.

4. Gocator Multi-Sensor Networking Capabilities

In the "smart" automated factory, networked smart 3D sensors connect with factory infrastructure to report results, web browsers for diagnostics and monitoring, the Internet for upgrades, and even with other sensors to exchange or combine data. Gocator Accelerator unpacks, stitches, and generates new point clouds with data from networked sensors.

The Master Hub 810 network controller simplifies the support of multiple sensors (up to eight) by handling power, synchronization, laser safety (for laser-based sensors), encoder, and digital I/O. A Master 810 is used to support the Volume Checker when you want to use four such sensors to scan and measure four cylinders at once.

Gocator Volume Checker demonstrates how 3D smart sensors, custom measurement tools, PC-accelerated applications, and hardware synchronization can be combined to solve specific applications that can't be achieved using standard measurement solutions.

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