# Inspection and Measurement of Engine Cylinder Bores

With NOVACAM™ BarrelInspect System

## Introduction

Manufacturers in high-precision industries like automotive, aerospace, and defence need to ensure the high quality of their products.

Engine cylinder bores, for example, are critical to the performance of the engines in automotive vehicles. To ensure quality of engine components, Quality Control requires performing dimensional and surface roughness measurements and identifying surface defects. Manufactured parts can have a number of defects, such as scoring, cracks, erosion, pitting, overheating, dents, or misalignment. Detecting and addressing these issues as early as possible in the manufacturing process is important.

NOVACAM™ BarrelInspect is an optical measuring system for non-contact 3D metrology of large tube and bore IDs from 90-190mm in diameter.

The system offers a wide range of micron-precision 3D measurement capabilities inside hard-to-reach spaces, a fully configurable automated inspection, time-saving automated reporting, simple scan definition and execution, and reduced inspection cycle time. It is also easily integrated into fully automated inspection setups and adaptable to hostile environments.

## Optical probe

The side looking optical probe is rotated while it advances inside the cylinder bore. It measures the complete inside geometry in a spiral pattern. Circular and longitudinal scans can also be performed and conical/tapered surfaces scanned.



Optical probes do not wear out like tactile probes do, thus there is no need for expensive consumables.

The standard scanning head measures 80 mm and is used for a bore diameter range between 90-190 mm. The probe standoff is adjustable, and the probe length measures 500 mm (for use in both horizontal and vertical orientations). Custom length probes can be offered on request.

## Example: engine cylinder bore defects

Cylinder bores can have various defects that impact engine performance and longevity. Compared to gasoline engines, diesel engine cylinder bores are more prone to certain manufacturing defects due to the higher pressure and stresses they endure. To maintain the integrity and performance of engines, over-heating, porosity, cracks, pitting, and excess wear must be addressed.

Engine design, materials used, operating temperatures, and manufacturing stresses can all contribute to cylinder bore issues. As the engine heats up when it is running, **thermal expansion** affects the metal in the cylinder bores, causing bore distortion, out-of-roundness, and tapering of the bore, which reduce the engine's efficiency and performance.

For this reason, high-performance engines like those of Formula One cars are preheated to maximize their performance. This helps to bring the engine components closer to their operation dimensions and reduces the risk of damage from thermal expansion during startup.

Another approach to mitigation is **cross-hatching** a cylinder bore to provide a surface finish that enhances the performance and longevity of the engines. Cross-hatching improves the sealing between the piston rings and the cylinder walls, resists wear by distributing the load evenly across the surface, supports the engine's break-in process, and helps retain oil on the surface of the cylinder walls to reduce friction between the piston rings and the cylinder walls. However, uneven honing can lead to bare spots on the cylinder cross-hatch pattern, which can lead to poor lubrication, increased wear, and greater friction. This can, again, generate heat (in the form of localized hot spots), which leads to uneven expansion and distortion of the cylinder bores.

Fig.: Novacam cylinder after circularity correction

## Measurement

The BarrelInspect systems address these issues by inspecting the surface of cylinder bores for dimensional-GD&T parameters, surface roughness, and defects. Then, image processing algorithms are used to detect and classify defects.

To measure the complete inside geometry, the probe tip rotates and advances into the cylinder bore in a spiral pattern, a circular pattern, or as a longitudinal scan. The MICROCAM™ interferometer provides the light source to the optical probe and processes the optical signal received from the probe. The probe is not sensitive to the environmental light. Probe and interferometer are connected with an optical fiber.

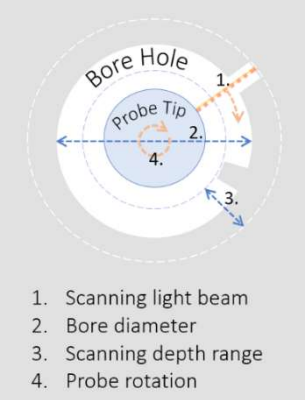



Fig.: Top view of scanning setup

The specifications usually include:

- Diameter measurement of the cylinder bore
- Defect detection of porosities, cracks, scratches by acquiring dense scans
- GD&T measurements inside large tubes, bores, barrels, etc.
- Length measurement of the cylinder bore
- Roughness measurement
- Angle of cross-hatch pattern
- Chatter measurement

## GD&T

BarelInspect's engine cylinder bore measurements reveal several Geometric Dimensioning and Tolerancing (GD&T) parameters that are crucial to function and performance.

*Cylindricity*: the bore must be uniformly cylindrical along its length (i.e. round and straight).

*Roundness* (circularity): the bore must be as close to a perfect circle at any cross-section as possible.

*Straightness*: the bore must be straight along its axis.

*Diameter*: the actual bore size, which must be within the specified limits.

*Surface finish*: the texture of the bore surface.

*Concentricity*: the bore axis must be centred relative to the datum axis.

*Parallelism*: the bore axis must be parallel to a reference plane/axis.

BarrelInspect's precise insight into these factors helps you ensure engine performance.

## Scanning setup & components

The NOVACAM™ BarrelInspect system is a fiber-based modular system that includes:

- Scanning head with probe tip
- MICROCAM interferometer
- Inspection station
- PC
- Motion controller(s)
- Optional multiplexing hardware

The station can be configured for horizontal and vertical inspection, depending on the application. The inspection station can be placed on the shop floor or in the lab, as well as set up for automated inline industrial inspections as part of a larger system.

A granite table is recommended for some applications, which is available upon request. Fixturing for the components is not included.

BarrelInspect uses NOVACAM's high-performance data acquisition software. An API is available to accommodate a wide variety of applications, and 3rd party turnkey solutions for full GD&T analysis can be purchased with the system.

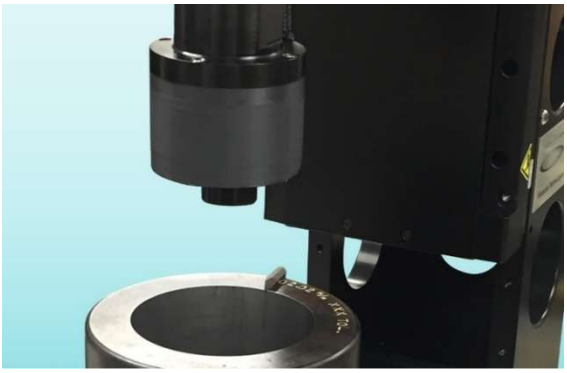


Fig.: The BARRELINSPECT system scanning a cylinder gauge

## Conclusion

BarrelInspect lets you measure engine cylinder bores and other high-performance components quickly and precisely. This powerful system is fully configurable and easily integrated in automated setups. BarrelInspect can be used as replacement for Incometer.

BarrelInspect is just part of Novacam's range of innovative and flexible measurement solutions. Contact us to discuss your manufacturing and quality control challenges.