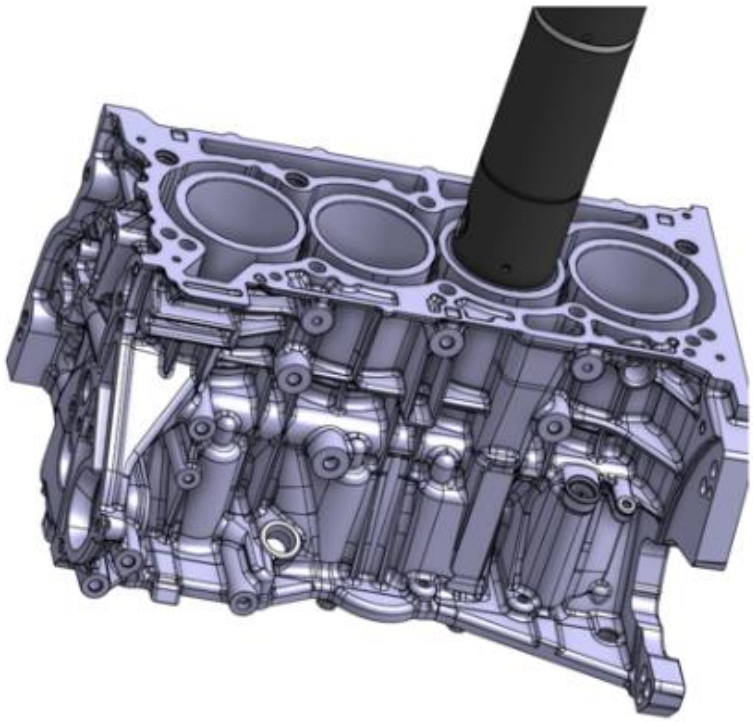
enovasense
BEHIND THE INVISIBLE



AN INNOVATIVE SOLUTION

FOR **100% THICKNESS CONTROL**

OF AUTOMOTIVE ENGINES

CYLINDER SPRAY COATING

A common patent **Enovasense - Renault Group** for contactless, non destructive, fast and high precision coating thickness inside cylinders

Background

Bore-Spray Coating is a technical innovation recently implemented in an increasing portion of automotive engines. Instead of using full iron casting cylinders, automotive suppliers use aluminum cylinders with an iron coating inside the cylinder in order to decrease dramatically the weight of the engine while keeping antifriction and hardness properties of iron.

Currently, 4 different possible coating processes exist for depositing the iron coating inside the cylinders:

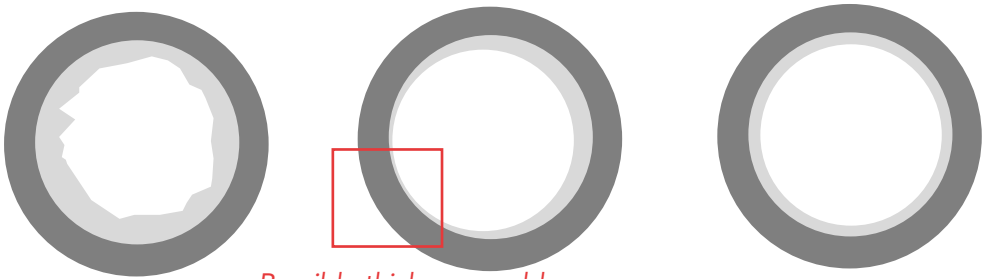
Powder plasma	**Wire plasma**	**Twin wire arc**	**Flame spray & HVOF**
a plasma is generated close to the coating zone and iron powder is projected into it	a plasma is generated close to the coating zone and an iron wire is sent into it	an electric arc is generated close to the coating zone and 2 iron wires are sent into it	a flame is created and iron components are sent with high velocity into it

Thickness measurement importance

After the deposition of this coating, a fine boring step allows to achieve a smooth surface with very low rugosity.

After this step 2 reasons make the remaining thickness of the iron coating important to monitor :

- It is difficult to control precisely the centering of the fine boring operation and an error in the centering will result in high thickness on 1 side and low thickness on the other side of the cylinder with the risk of leaving not enough coating thickness in some positions.



Before boring *Wrong boring centering* *Right boring centering*

- The aluminum surface has a high rugosity and a deep threading which make it difficult to be sure there is a minimum iron thickness remaining in all positions of the cylinders

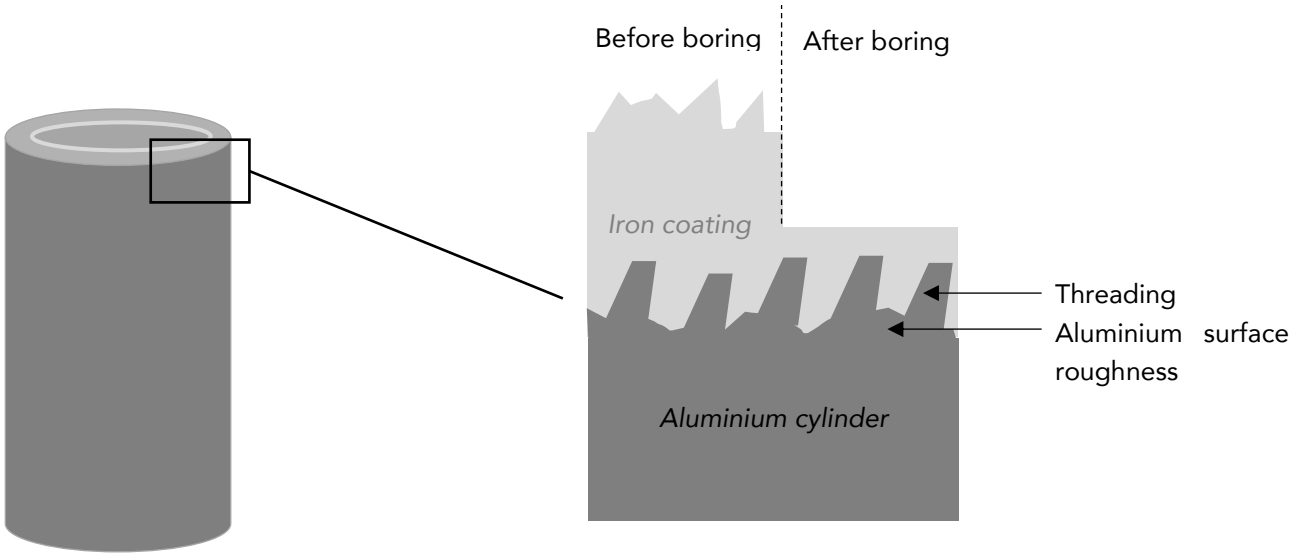


Figure 1: Bore Spray Coating

Measuring the thickness of this coating in several angles and heights in each cylinder is so important to ensure quality and durability of the engine but also to assess any drift in the coating and boring processes.

Currently, engine manufacturers perform destructive measurements (cross section and microscope) for example on 1/5000 engines. As at least 12 positions per cylinder have to be measured, the whole measurement operation for the several cylinders of an engine takes about 1 week.

Some nondestructive contact magneto-inductive devices have been tested with good correlation to the destructive technique allow to decrease the time to measure a complete engine block. But they are not fit to implement in-line on 100% of the engine block due to the complexity of automating a good contact between the probe and the inside of the cylinder.

The case for non-contact nondestructive in-line measurement

Comparative trials have been held by Renault and Enovasense between cross section microscopic method (destructive), magneto-inductive technique (contact) and Enovasense laser photo-thermal radiometry device (noncontact, nondestructive).

The comparison study shows higher accuracy results with Enovasense non-contact technique than with contact probe.

Moreover, the reproducibility of Enovasense measurement is clearly higher than the contact probe. Other photothermal radiometric devices show in separated published tests performed after the boring step (on reflective surface) some reproducibility values going from 3 to 6% of the measured value, results going from 10 to 20 times less reproductible than Enovasense results.

General Presentation of the control System for in-line inspection

The system includes everything required to make a full measurement of all cylinders of the motor block. A loading rail allows safe and repeatable positioning of the motor block, a 3 axis cartesian robot is used to scan any cylinder for any kind of motor, automated rotation of the Enovasense measuring head to scan 360° inside the cylinder. A Reference sample container is also included for automated calibration. A 27 inches touch screen allows data visualization as well as set up of the device.

The system is divided in 3 independent structures.

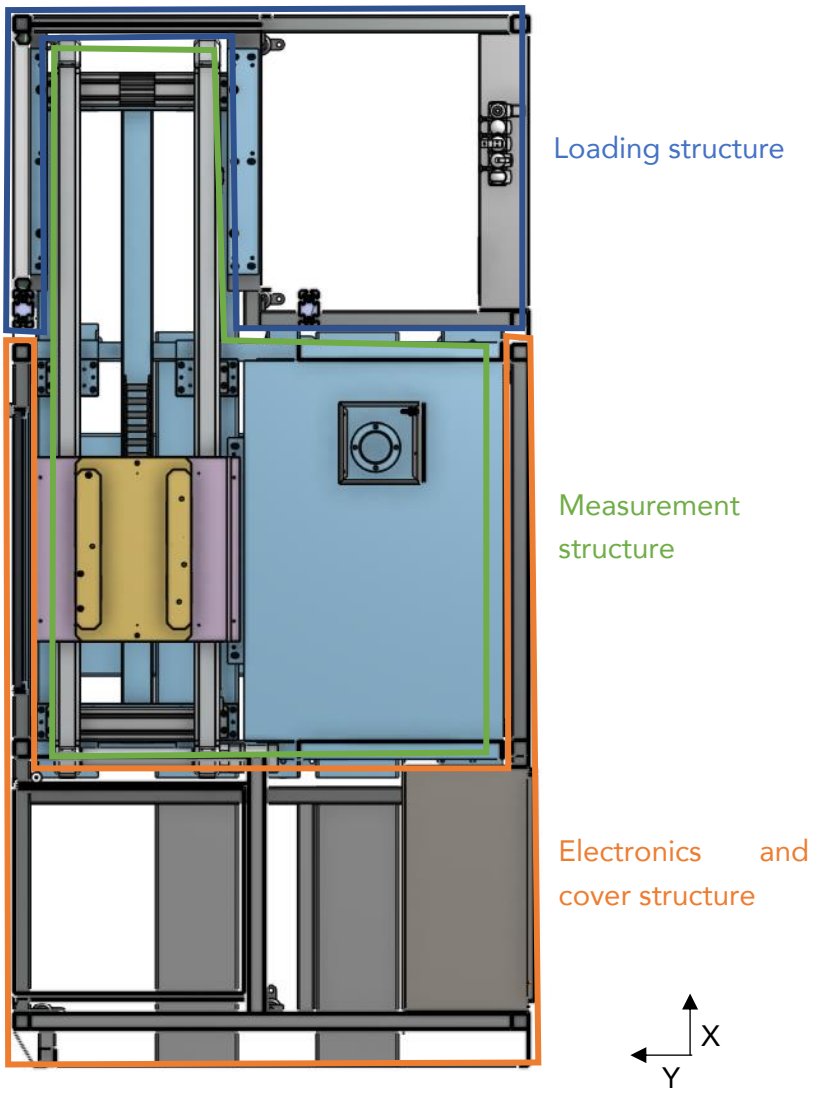


Figure 2: System XY cross section

Those structures are independent so that no vibrations or shocks are transmitted to the measurement.

Loading structure

The loading structure is independent from the measuring structure of the system so that during robot loading a faulty trajectory that would bump this area does not damage or temper the alignment of the rest of the system.

Measurement structure

The measurement structure holds the 3 scanning axes and the loading axes. It is independent from other structures.

Electronics and cover structure

This structure holds the electronics, the HMI and the cover of the device.

System main elements and areas

Measuring head

The measuring head designed by Enovasense allows insertion inside each cylinder blocks to measure the coating thickness. The measurement is done at the center of the exit lens.

The bottom part of the measuring head can rotate to scan 360° inside the cylinder block (Figure 6). Air is continuously blown on the lens to avoid contamination. Multiple heads can be used to scan several cylinders at once.

As of standard the measuring head diameter is adapted to measure 72.2mm diameter cylinders, this can be changed based on specifications by changing the focal length of the exit lens.

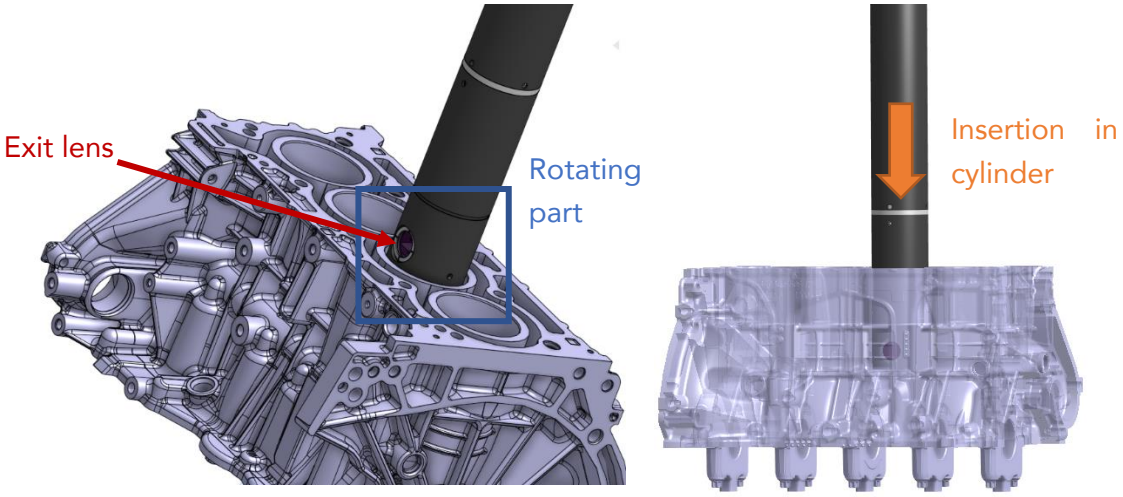


Figure 3 : Measuring head

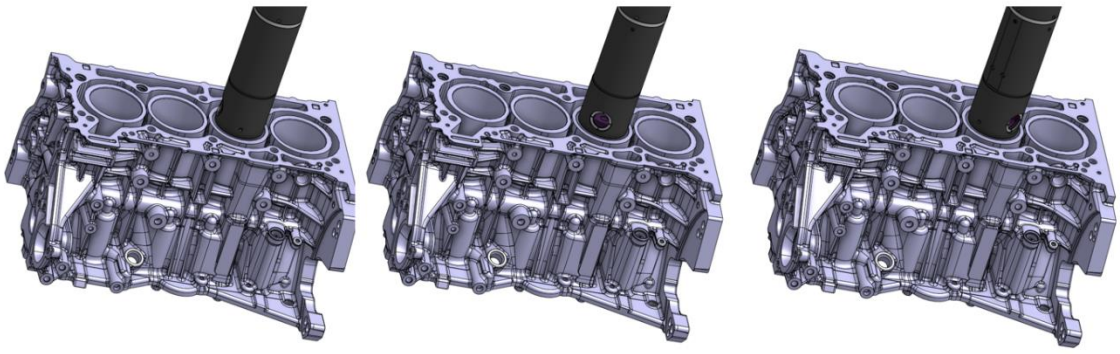


Figure 4: Measuring head rotation

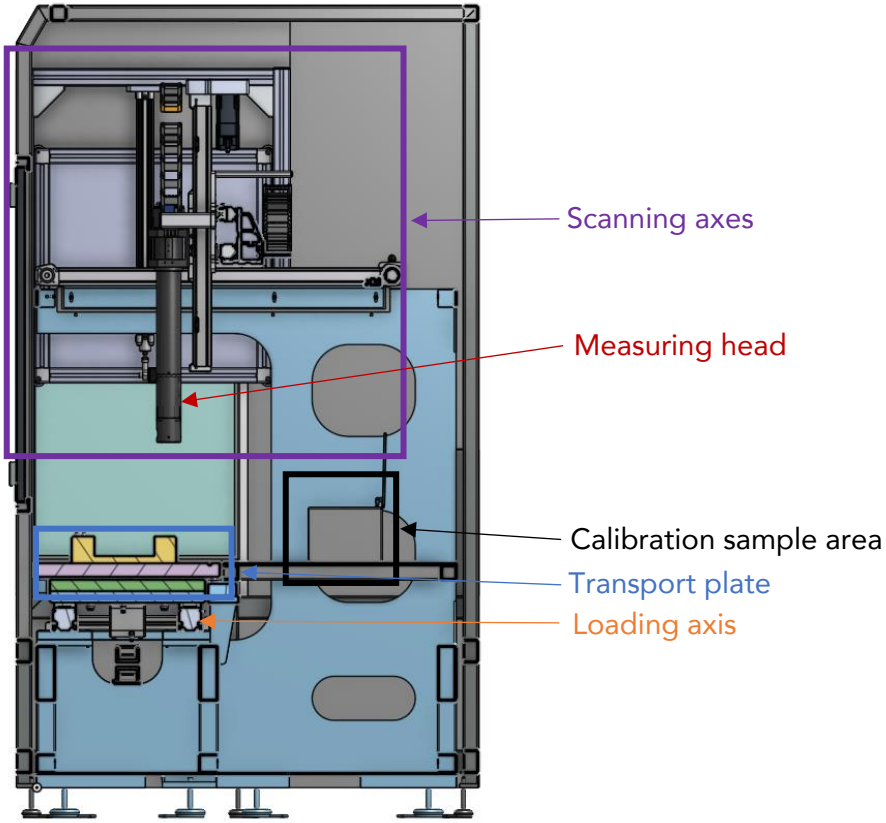


Figure 5: System XZ cross section

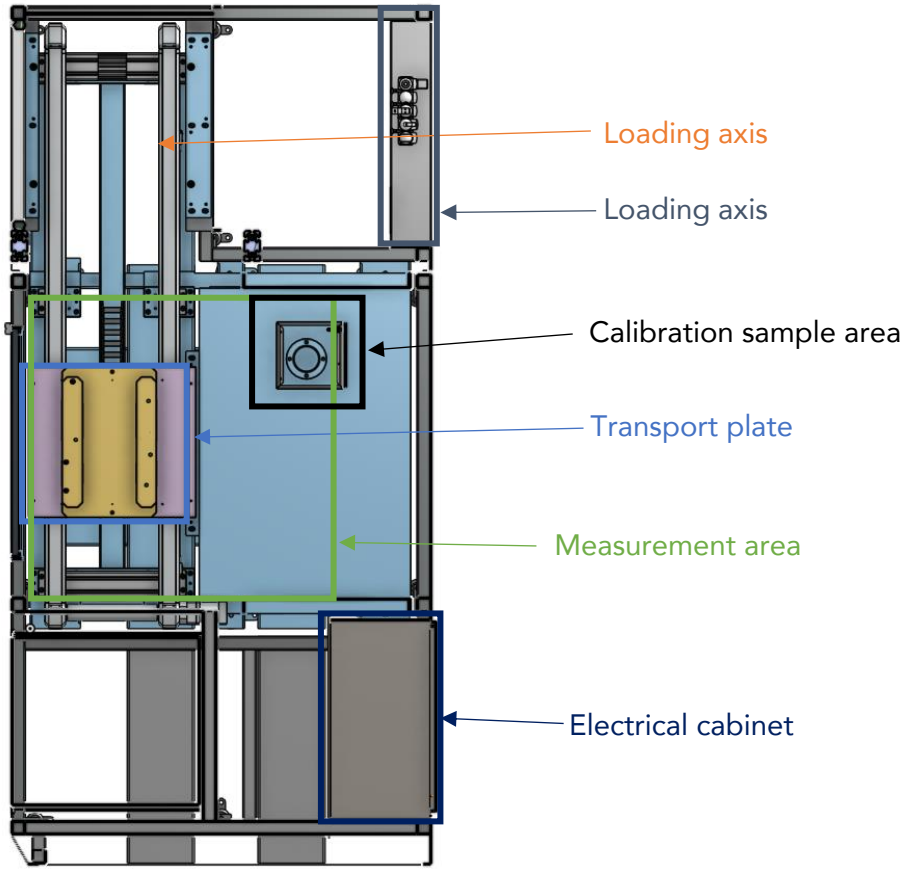


Figure 6: System XY cross section

Loading axis

The loading axis is composed of two belt driven axes. It moves the part from the loading area to the measurement area. The part is lifted from the loading area with a pneumatic actuator and then deposited in the measurement area on referenced cones.

As off standard in the product are used Hiwin axis, Siemens motors and a Festo actuator. Different suppliers are possible upon request.

3 scanning axes cartesian robot

This system is constituted of two sets of belt driven X and Y axes and of one Z screw ball axis. Those axes are used to position the head at selected locations of the cylinder block.

As of Standard the axes give 600x800x400 mm3 of run. This can be adjusted but will of course have an impact on the global size of the device. Here also are used Hiwin axes and Siemens motors.

Loading area

This area allows the loading of the part on a plate that will be transported into the measurement area by the loading axis. This area is secured using light curtains to protect the operator against moving parts.

Axes rest area

In this area, the axes and the measuring head are protected and not in the trajectory of the loading axis.

Calibration sample area

This area is used to safely store a calibration sample. After a defined number of measurement cycles, this sample is measured to ensure calibration and standardizing of the measurement.

Measurement area

The measurements can be taken inside this area (600x800x400 mm^3 as a standard). This area includes referenced cones to receive the plate carrying the part. The referencing between the plate and the 3 scanning axes in this area can be done very precisely and automatically using a palping probe (Renishaw as of standard) and a dedicated software.

Electrical cabinet

Contain all the automation and Electronics. The PLC used is a S7-1500 Series Siemens PLC. The Computer is a Siemens industrial computer. All design and assembly has been done according to EU norms and standards and to Renault Norms found at www.cnomo.com

Pneumatics Cabinet

Contains all air management. All design and assembly has been done according to EU norms and standards.

Main Caracteristics:

Complete size	2600x1300x2200
Weight	600 kg
Laser Power	10 W
Laser Wavelength	980 nm
Power Supply	400V, 3KVA
Air Supply	5 bars
Cycle time (4 cylinders block, 2 heads, 12 points/cylinder)	50s
Measuring head Diameter	66 mm
Measuring area size	600x800x400 mm3
Reproducibility	< 1 µm

Those are given as an indication. They can be adapted to specific customer requirements.

About Enovasense

Enovasense develops an innovative technology for the control of the thickness of all kinds of coatings (paint, polymers, organic, ceramic, metal, clearcoat, glue, etc) on all kinds of substrates.

This laser device allows a quick punctual measurement, without any contact with the part to measure and nondestructive. Moreover, the innovative measuring head of Enovasense device is the most compact and easy to use existing.

Those advantages allow to control the thickness of up to 100% parts into the production lines.

The non-contact measurement allows to have a real-time feedback of the deposition process, even on parts on which the coating is for example still wet, not polymerized, hard to reach, or on parts that are moving in the production line, still hot, etc...

Industrial process optimization, material savings, higher quality level, better production monitoring, time saved on measurement... there are plenty of gains sources for industrials.

Enovasense has implantation references in Europe and Asia on a wide range of markets such as automotive, aeronautics, metalworking, housing, consumer goods, watchmaking, jewelry...

Enovasense technology, worldwide patented, has been awarded at World Innovation Challenge and French Research Ministry Challenge. It has also been awarded best Factory of the Future technology by SKF. Enovasense is a team of R&D engineers specialized in optics and photonics, focused on their core competences, assisted by a scientific board, a strategic board and a venture capital fund.

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