Measurement report

Subject: Demonstration of the principle of operation and the possibilities of the SMARTTECH 3D scanner along with software, Geomagic Control, in collecting information about the volume of combustion chamber on the piston.

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1. The purpose of the measurement

The aim of the measurement conducted by SMARTTECH3D is to show the principle of operation and possibilities of scanning the combustion chamber of a piston in order to measure its volume.

To perform the calculation of the volume of the combustion chamber of a piston, we need:

- to scan (obtain the geometry of) the researched object
- appropriate software

2. 3D scanning - obtaining the geometry of the object

The first step is to scan the object. If the scanned object is glossy or transparent we need to cover it with titanium oxide. It will dull the object (allowing us to perform a more accurate measurement). Next, we have to scan the element. In this case we used the scanner scan3D qualify 5MPix with 300 mm x 200 mm x 210 mm measurement volume and with 0.03 mm of accuracy.

The result of a single scan is a point cloud (every point is described in x, y, z coordinates).

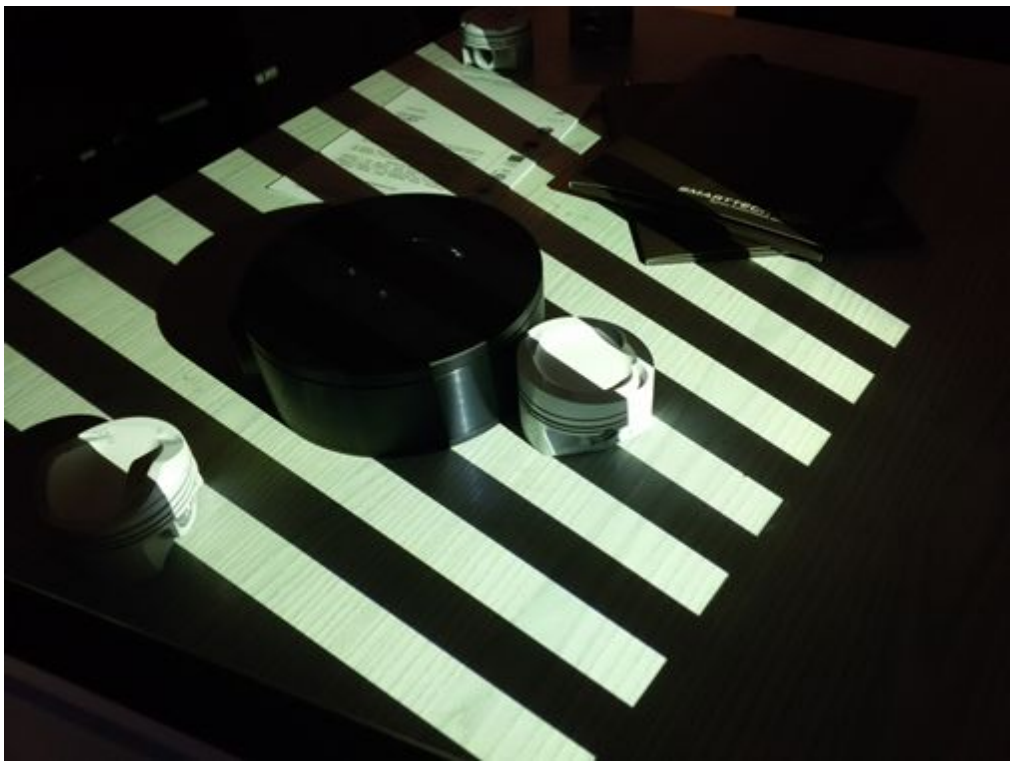


Figure 2.1 The scanning process

3. Work in SMARTTECH3Dmeasure

The SMARTTECH3Dmeasure is used to control the 3D scanner. This programme displays the result of the measurement (the point cloud) on the computer screen. The measurement can be performed using 3 different methods: 1) a single measurement, 2) with the use of a rotary table or 3) a measurement with markers. In SMARTTECH3Dmeasure we select the parameters appropriate for: the chosen type of measurement, the object and for the environmental conditions. The software also allows for the exportation of the point clouds in a .ply format. This format is compatible with most reverse-engineering programs that are based on a point cloud (including Geomagic software).

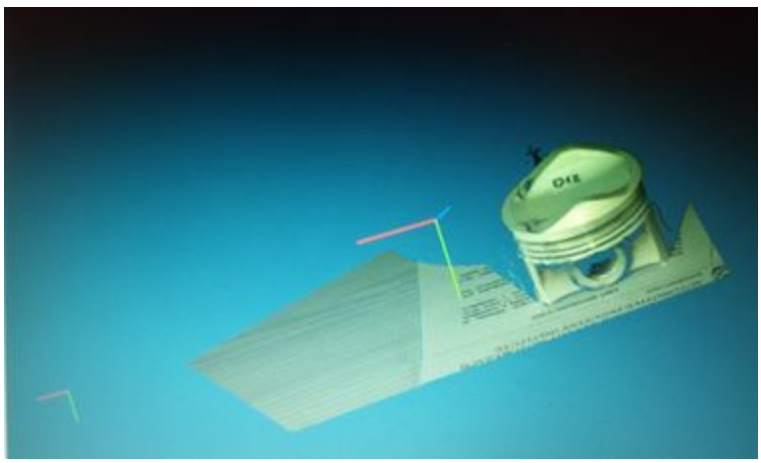


Fig. 3.1 Example 3D scanning result from SMARTTECH3Dmeasure.

The upper surface of the piston was covered with titanium oxide and then scanned.
The number of performed measurements was between four and six depending on the complexity of the construction of the piston.

To automate the process a rotary table can be used.

4. Aligning point clouds in Geomagic Control.

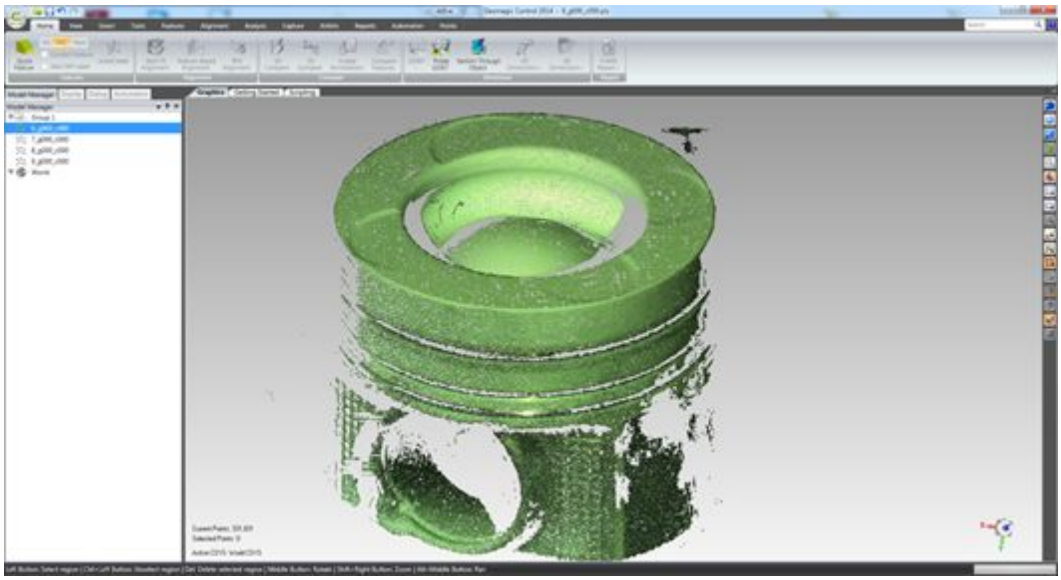


Fig. 4.1 View of the point clouds in Geomagic Control.

At the beginning, we have to import the point clouds that we want to align. The first step is to clean the point clouds, a manual and automatic noise search.

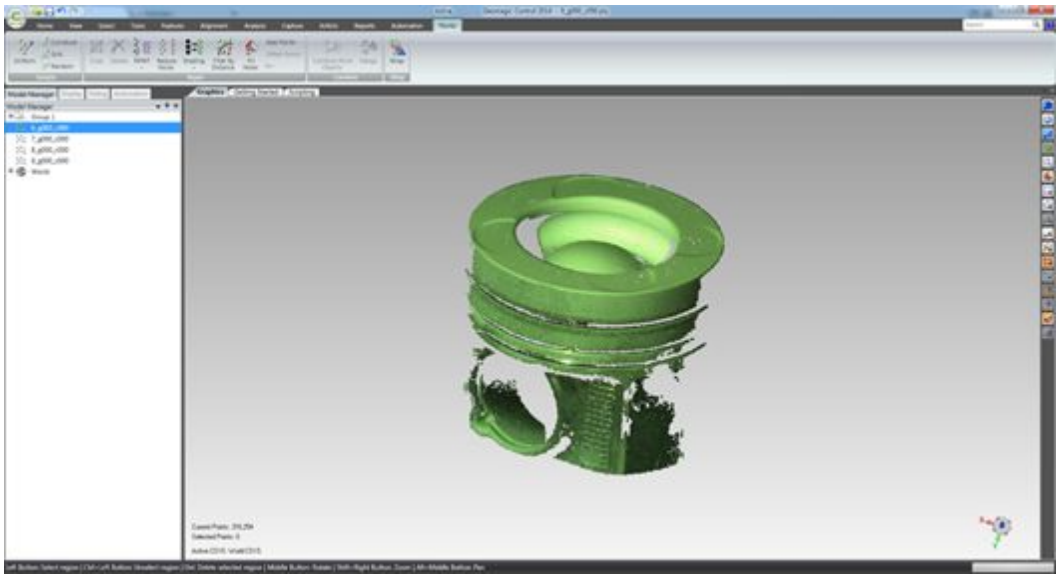


Fig. 4.2 View after the noise cleaning in Geomagic Control

This is an automatic option which first requires the cleaning of the point cloud from noise and other errors. For this purpose we use the option of finding 'outliers' (points separated from others) and 'disconnect components', and then, we remove them. The process of cleaning, depending on the size of the point cloud and the computer on which the software is installed, takes around 30 seconds.

The next step is to roughly align the point clouds using the method ‘on three points’, and then to align it more accurately using the option ‘global registration’. It will, in this case, align the scans at the level of 25 microns between individual measurements.

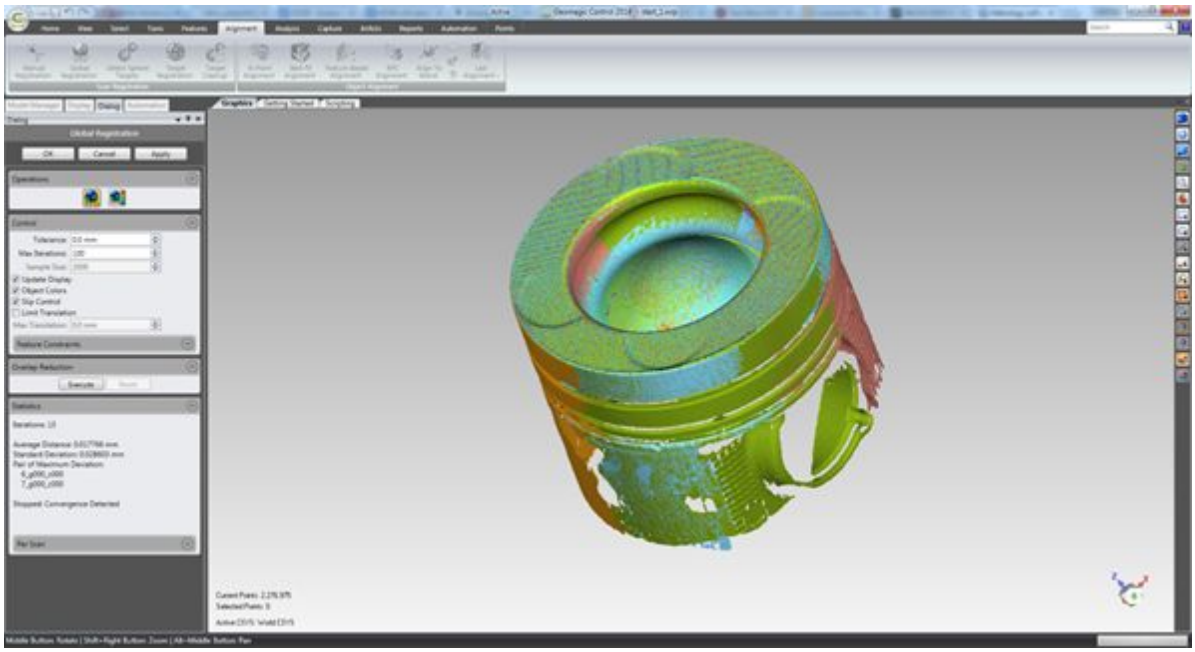


Fig. 4.3 Accurate aligning in Geomagic Control.

After aligning all of the point clouds we create a triangle mesh. The process is automatic and the results are obtained after around a minute.

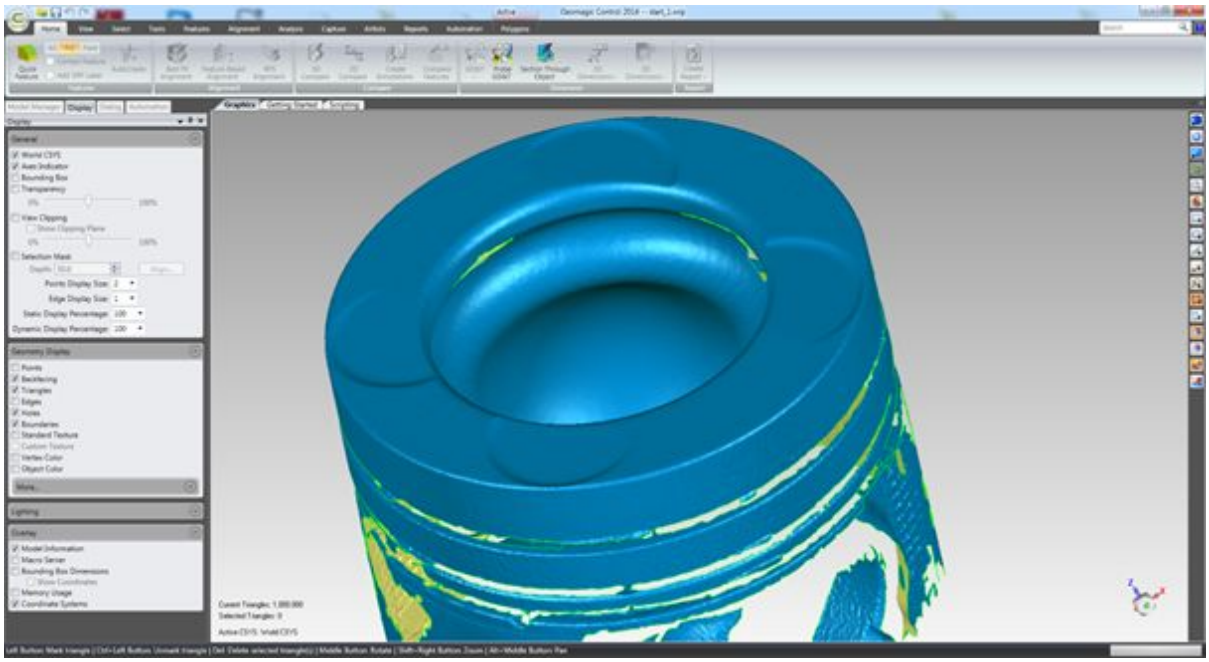


Fig. 4.4 Triangle mesh in Geomagic Control

Thus obtained triangle mesh is prepared for the process of volume measurement. The preparation involves cutting off the redundant part of the triangle mesh. The preparation process takes around 2-3 minutes.

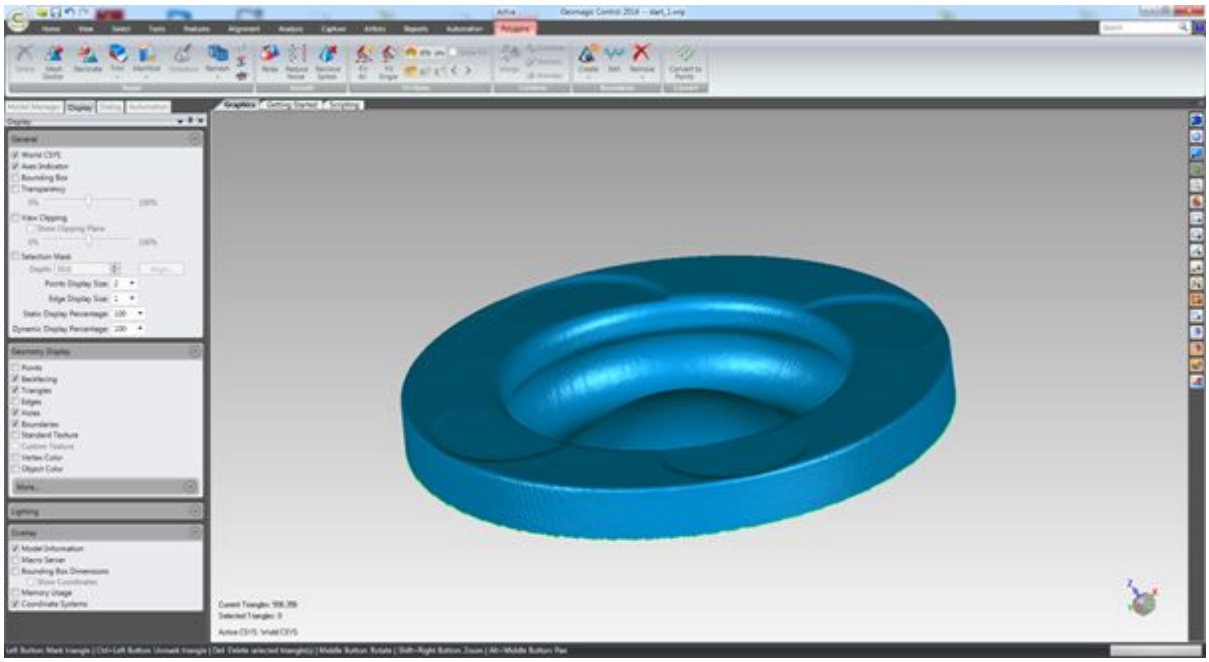


Fig 4.5 Prepared triangle mesh in Geomagic Control.

5. The analysis of the results in Geomagic Control (calculating the volume of the combustion chamber)

The advantages of the programme are:

- complex verification
- simpler and more reliable control of the parts
- import of the data from a 3D scanner and CAD type programs
- automatic alignment of the 3D scan to the CAD model
- creation of the deviations map and control of the dimensions and tolerations (GD&T)
- automatically generated reports make it easier to present the inspection results
- repetition of the process for another part with only two clicks of the mouse.

On the prepared area we define the reference surface.

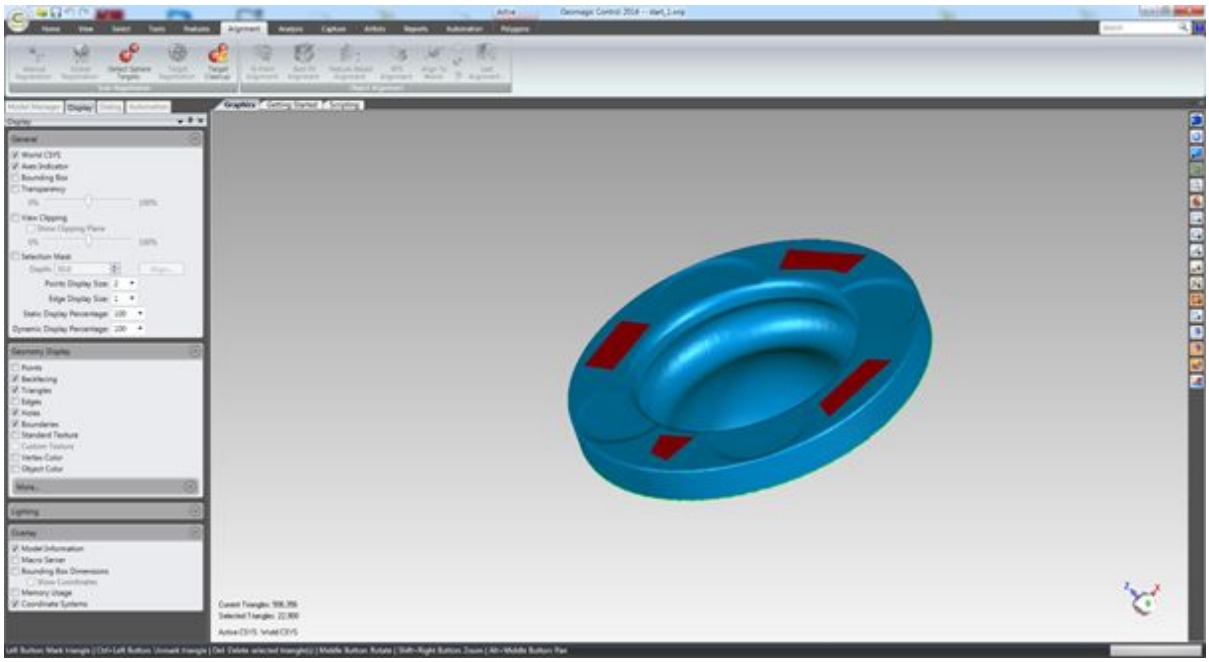


Fig. 5.1 Areas used to create a reference plane.

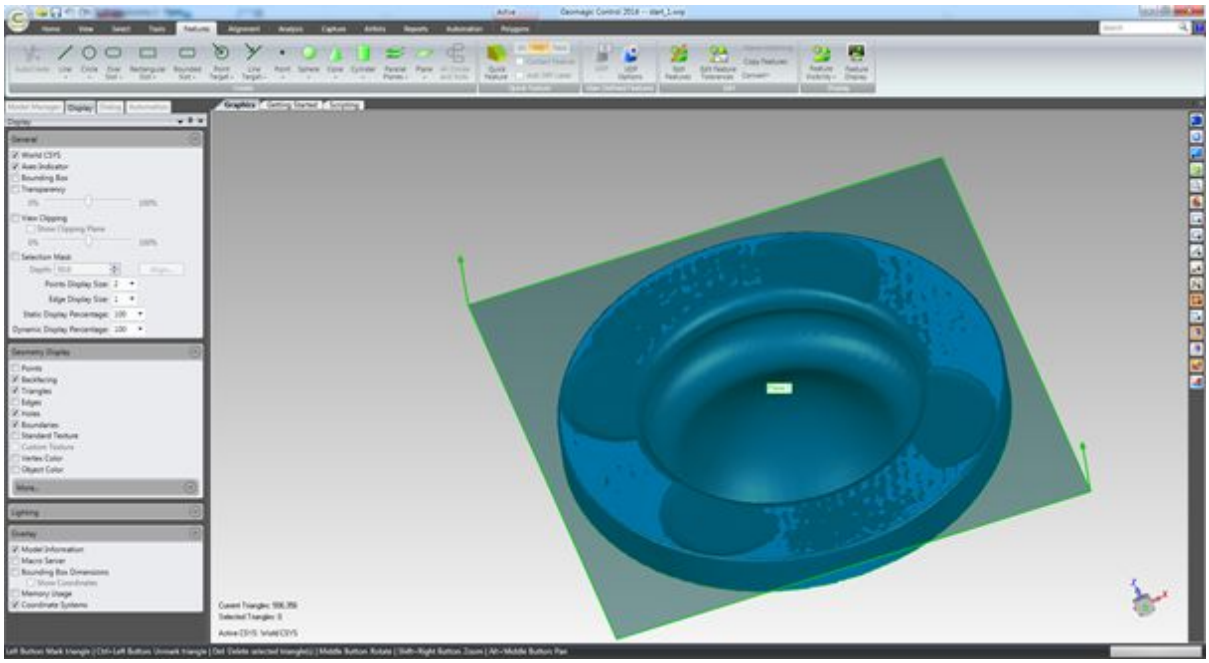


Fig 5.2 Areas, a reference plane, to which a piston volume was calculated.

We can now select the option of volume measurement.

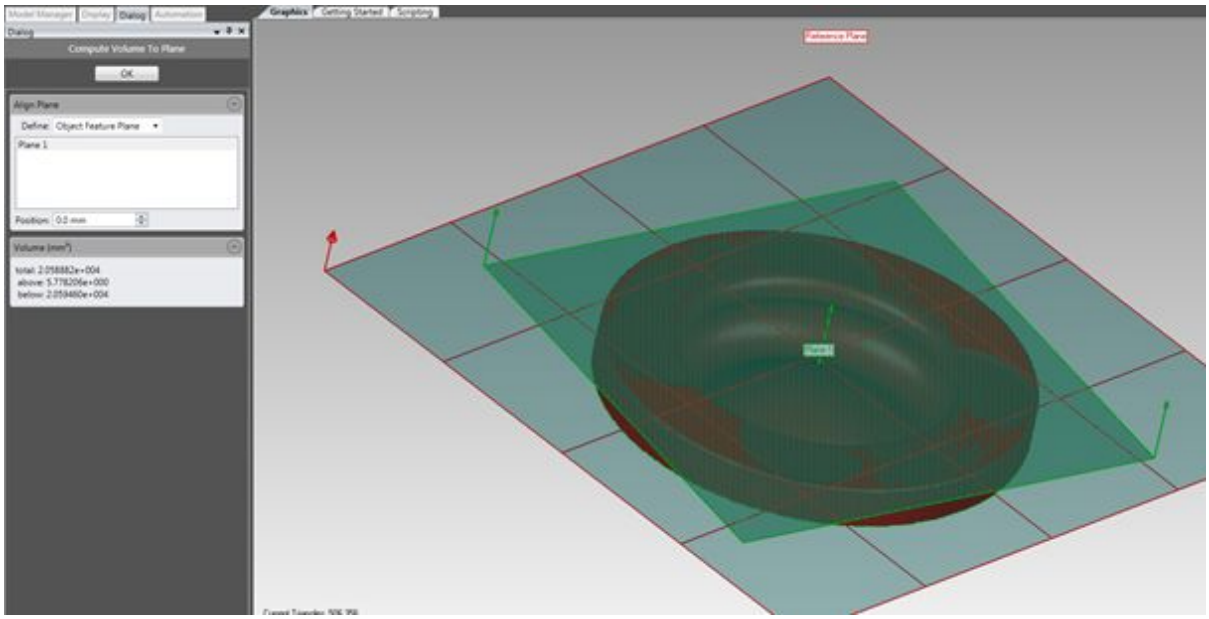


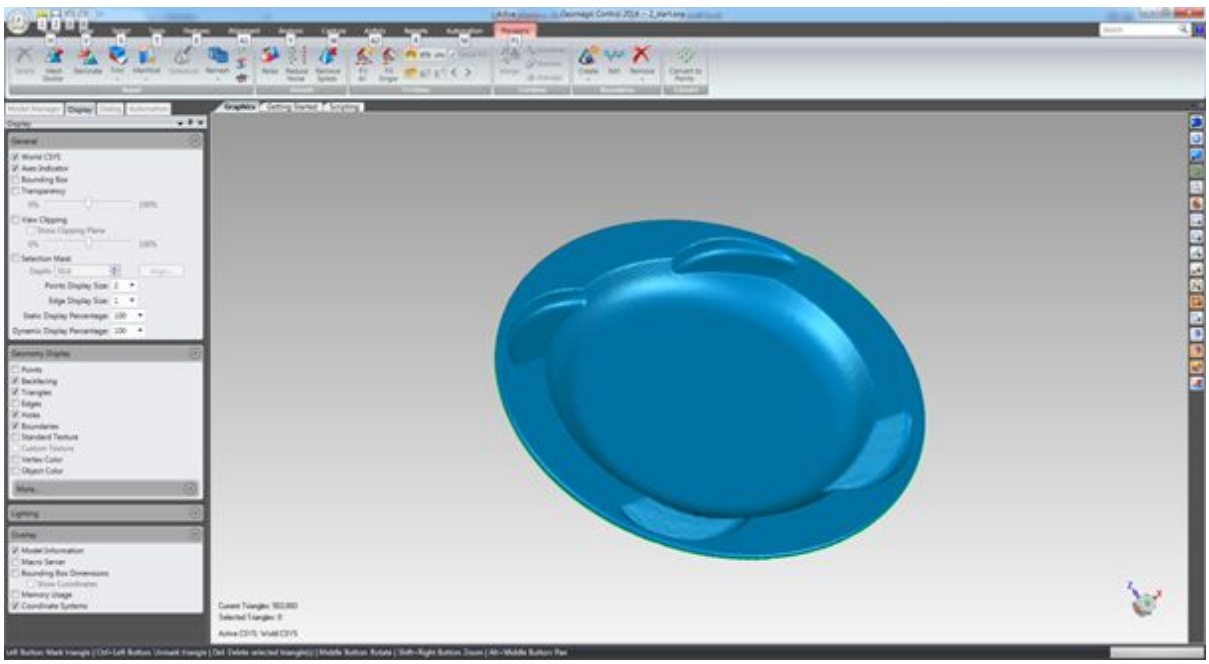
Fig. 5.3 Areas used for the creation of the reference plane..

Determined value: 20.58 cm^3
Expected value: 20.48 -/+ 0,3 cm^3

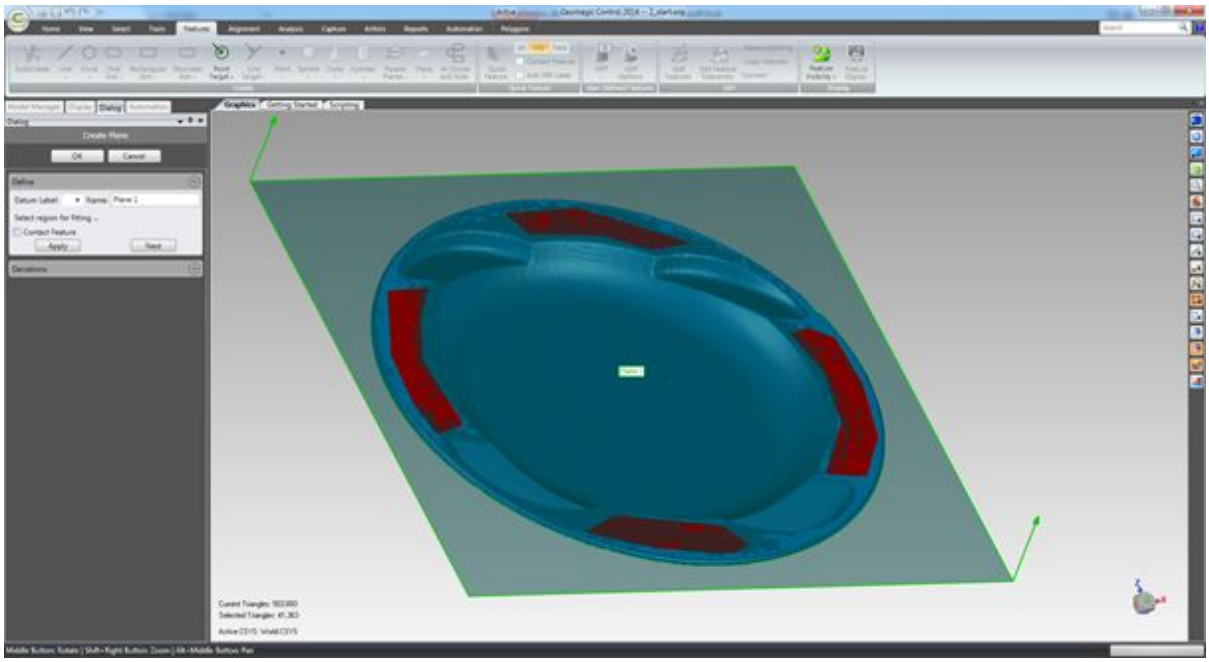
The entire process was performed for the remaining 3 pistons.

Second piston:

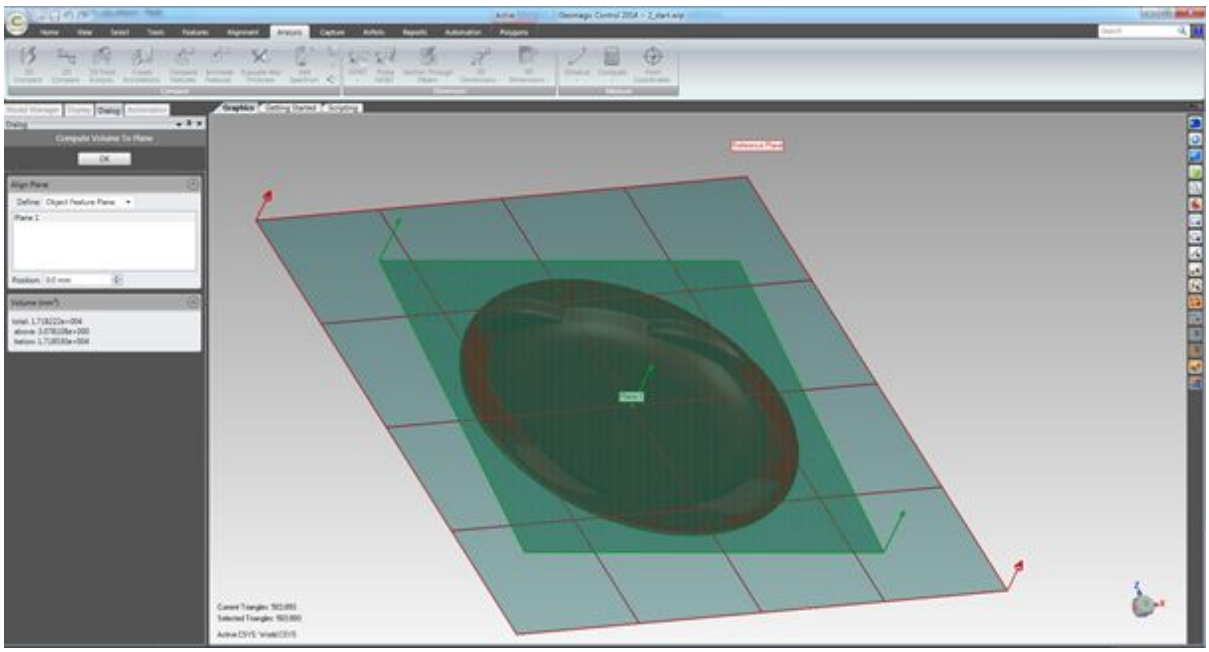
Triangle mesh:



Determining the plane:



Calculations:

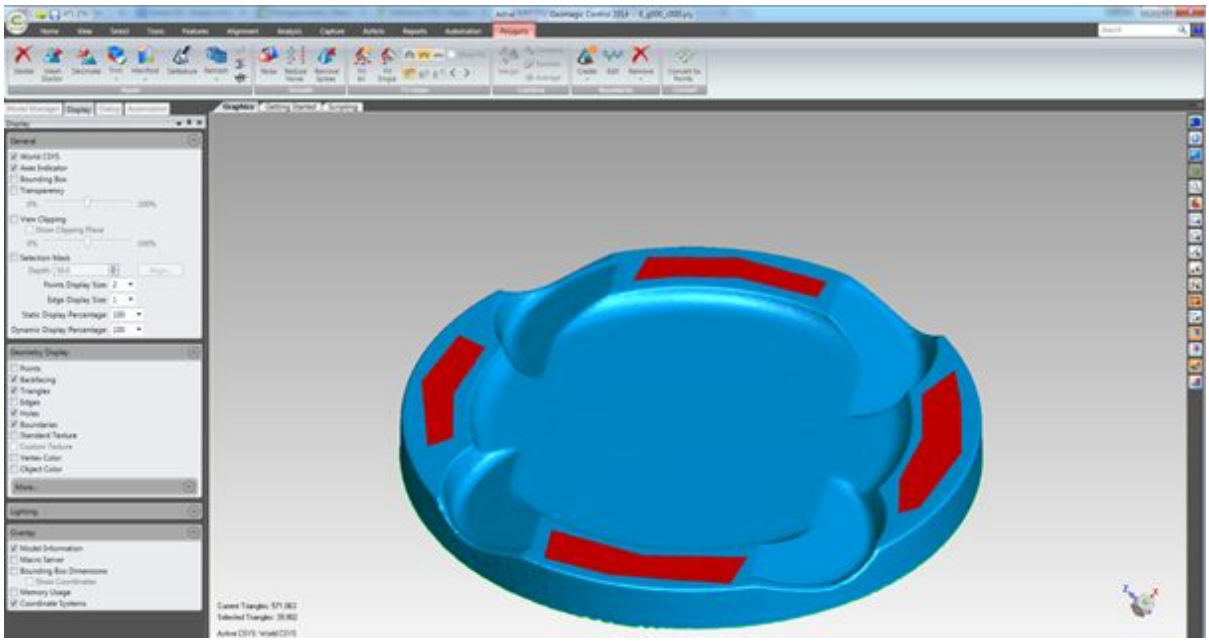


Determined value: 17.18 cm^3

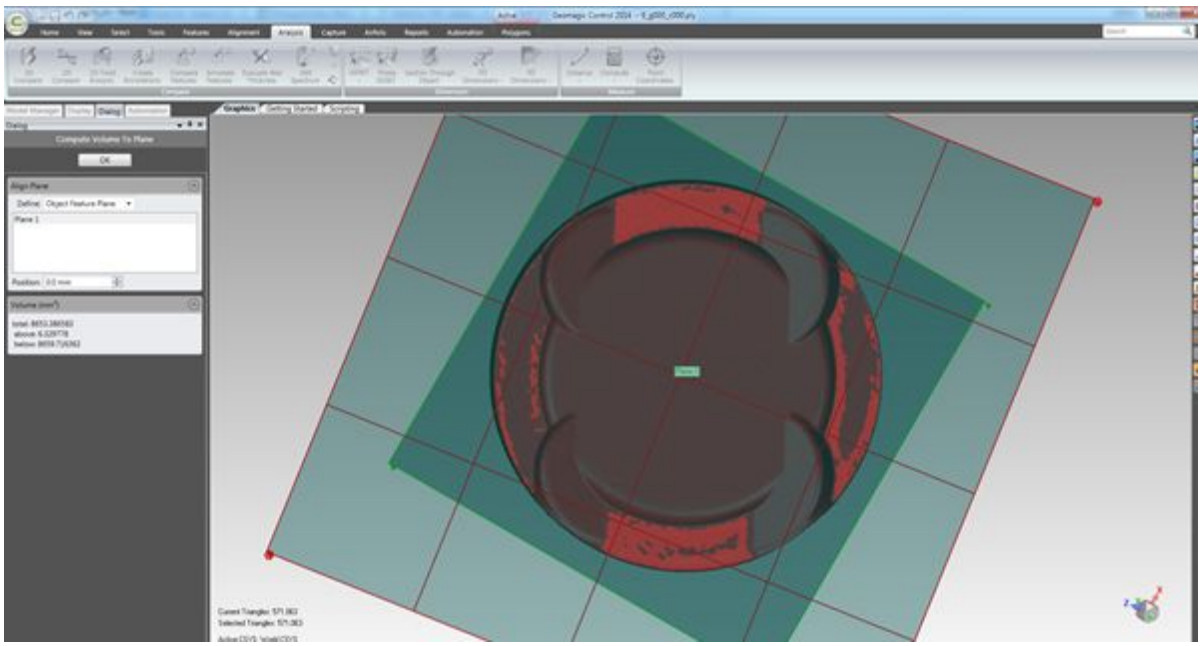
Expected value: 17.3 -/+ 0,5 cm^3

Third piston:

Triangle mesh/determination of the reference surface:



Calculations:

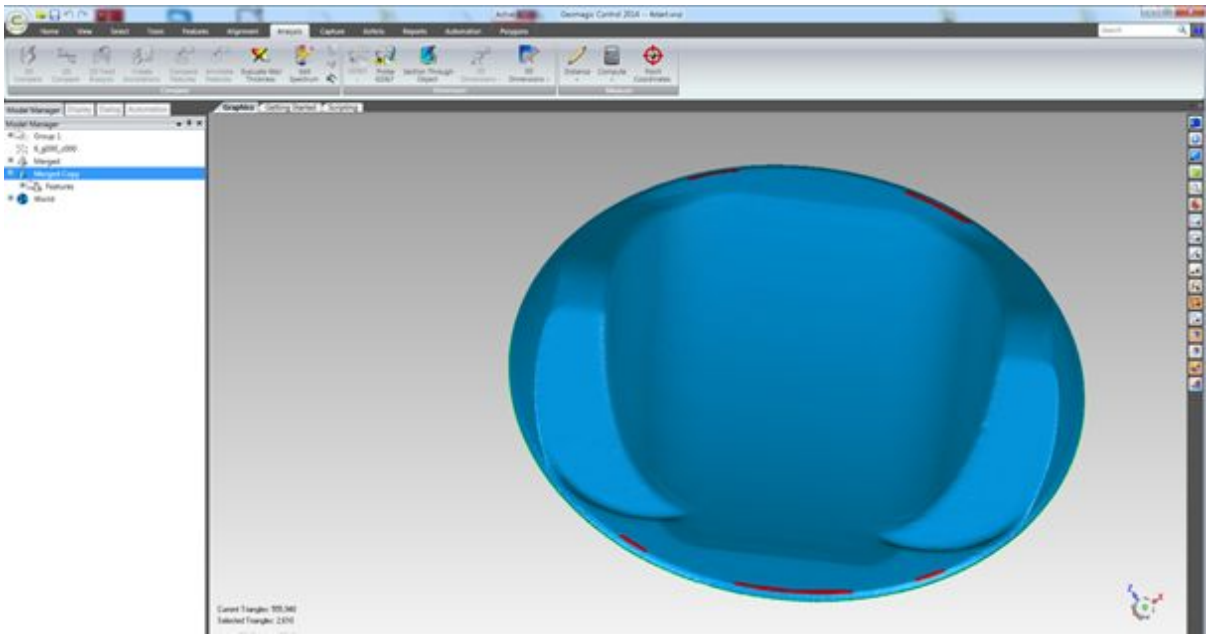


Determined value: 8.65 cm^3

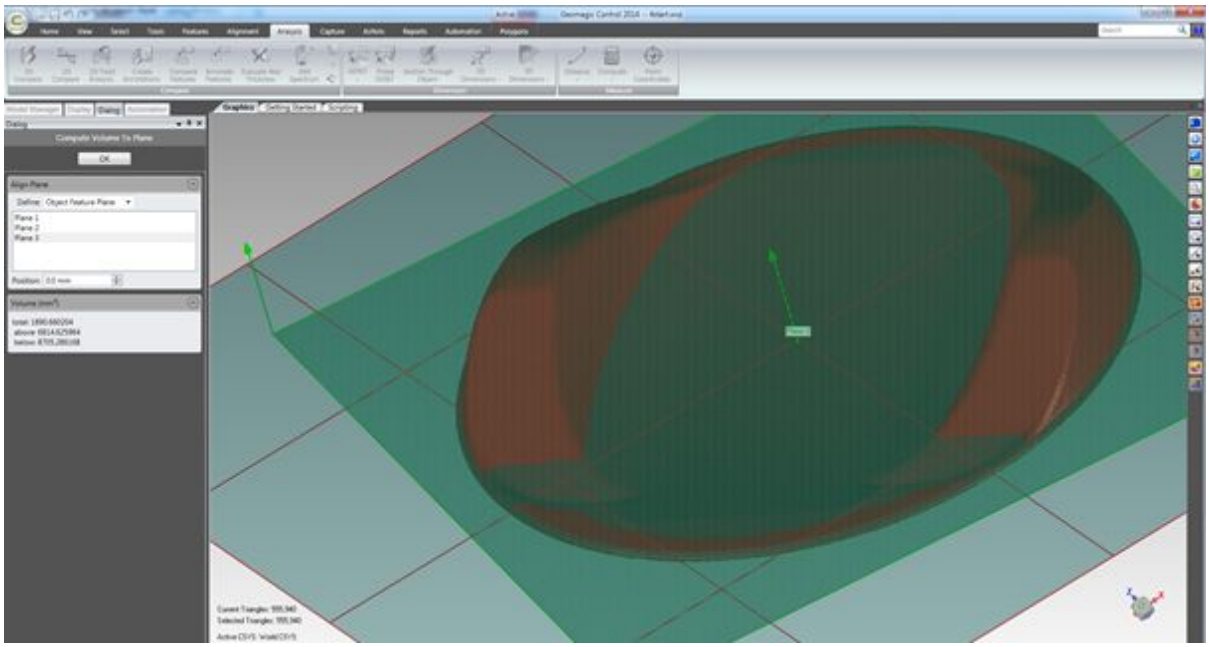
Expected value: 8.69 -/+ 0,5 cm^3

Fourth piston:

Triangle mesh/determination of the reference surface:



Calculations:



Determined value: 1.89 cm^3

Expected value: 1.52 -/+ 0,5 cm^3

Summary of the results:

Lp.	Calculated value	Expected value
Piston 1	20.58 cm^3	20.48 -/+ 0,3 cm^3
Piston 2	17.18 cm^3	17.3 -/+ 0,5 cm^3
Piston 3	8.65 cm^3	8.69 -/+ 0,5 cm^3
Piston 4	1.89 cm^3	1.52 -/+ 0,5 cm^3

The measurement method using the 3D scanner and Geomagic software that was recommended by SMARTTECH fulfills the requirements of the company. We achieve satisfactory results in a very quick and verifiable way. The SMARTTECH's 3D scanner can be also used for other applications, e.g. for reverse-engineering.

Summary

The demonstration showed that the 3D scanner meets the requirements.

The scanner scan3D qualify was used for the measurement which has a measurement volume of 300 mm x 200 mm x 210 mm allowing for the accuracy of 0.03 mm. Using a scanner with green light (right now, SMARTTECH is the only company with this technology) allows us to obtain a 30% higher accuracy than when using white light.

The SMARTTECH's 3D scanners don't require recalibration before they are used for measurements. That is because of the enclosed casing and a special ISA (Internal Shock Absorber) system. Scanners from SMARTTECH can be certified by independent measurement laboratories, which makes them referential for external entities.

The main advantages of using 3D scanners from SMARTTECH for performing the measurements of pistons:

- Recalibration is not necessary before taking the measurements (the entire measurement procedure is much faster than when using a 3D scanner that requires recalibration every time before taking the measurements). It also assures us that the 3D scanners have the appropriate accuracy.
- in order to attain the geometry we need between 3 and 6 measurements depending on the type of the piston.
- one measurement cycle takes around 4 seconds.
- the entire inspection process (from scanning to the measurement of the volume) takes around 10 minutes. The time can be reduced as the operator gains experience.
- there is a possibility of using a rotary table which can speed up the process of aligning all the point clouds together.
- possibility of covering the object with a dulling solution in the form of powder with the thickness of particles equal 3 microns that doesn't interfere with the measurement.
- the second advantage of this solution is that it's easily removable from the object.
- the 5 MPix detector allows us to achieve a high resolution of 73 points per mm^2 with the measurement volume of 300 mm x 300 mm x 200mm. It allows for a very accurate reproduction of the surface.
- each point cloud is saved to a separate file which allows for later modification and control over the alignment of all the measurements together..
- using Geomagic Control we are able to do measurements that wouldn't be possible using traditional methods..
- the entire processing cycle (from scanning to volume measurement) takes around 10 minutes.
- ability to generate a report in the form of PDF3D.

The advantages of buying a 3D scanner from SMARTTECH:

- we are a European producer of 3D scanners with 16 years of experience.

- the ability to create a system for the customer’s needs.
- rich experience with 3D scanning that we are very happy to share with our customers.
- we are an authorised distributor of Geomagic software and we conduct professional training on how to use it. The combination of this with our 3D scanning experience produces the best results.