Case study

3D scanning verifies the precision of objects printed on 3D printers

Quality control: inspection of 3D printed supercar part
3D scanner: MICRON3D green 10 MPix
3D printer: Factory 2.0 Production System
Software: SMARTTECH3Dmeasure, Geomagic Control X, Simplify3D
Industry: automotive

Arrinera Technology S.A. uses 3D printing in two fields – prototyping and final part production. Arrinera is a partner of OMNI3D – a manufacturer of industrial 3D printers. In the case of final parts the accuracy of the print and the maintenance of the adequate strength are very important aspects. The model must perfectly match the rest of the components and withstand high temperatures.

For the car manufacturer this was particularly important for the 3-way light mount design that was used as a final part of the Hussarya 33 front lamp. Arrinera wanted to thoroughly verify the dimensional accuracy before the installation. Quality control has been commissioned for SMARTTECH which specializes in the manufacturing of optical 3D scanners.

3D printing process

Since 2016 Arrinera has outsourced to OMNI3D all its 3D prints. OMNI3D not only produces industrial 3D printers in FFF technology but also offers custom 3D printing services on demand. The 3D printing process starts with importing the 3D model into software that will prepare an executable file for the printer. The Factory 2.0 Production System from OMNI3D is compatible with professional software – Simplify3D. The aim of the 3D printing technology is to produce the best print quality. The technologist must not only properly set the printout on the work platform but also has to verify the automatically generated supports, select the infill, the print layer and the filament type.

Fig. 1. *Supercar Hussarya 33.*

All these elements directly affect the print quality, strength, weight and the print time:

1. The 3D printing specialist must know how a particular print will be used and which plane has to be the strongest, as the FFF models have less durability in one of the axes.
2. The strength of the print is also influenced by its filling, which simultaneously defines the product weight and print time.
3. In order to increase the strength of 3D printouts appropriate internal structures such as "honeycombs", "lines" and 100% fill up are also used.
4. Selection of supports – their quantity and location – affect the geometry of the object. Supports allow to print elements of very complex shapes, sometimes even impossible to produce in other technologies.
5. The printing layer mainly affects the execution time. Using the 0.14 mm layer, the printing process can take up to twice as long compared to using the 0.2 mm layer.
6. It is also important to choose the right filament. Depending on the needs we choose a material that is more durable, easier to handle or UV resistant.

After defining the above settings the printer executes the printout. The 3D printer works in FFF (fused filament fabrication) technology building models by applying layers of molten plastic, which as a result of its temperature drop, coalesces to the full height of the model.

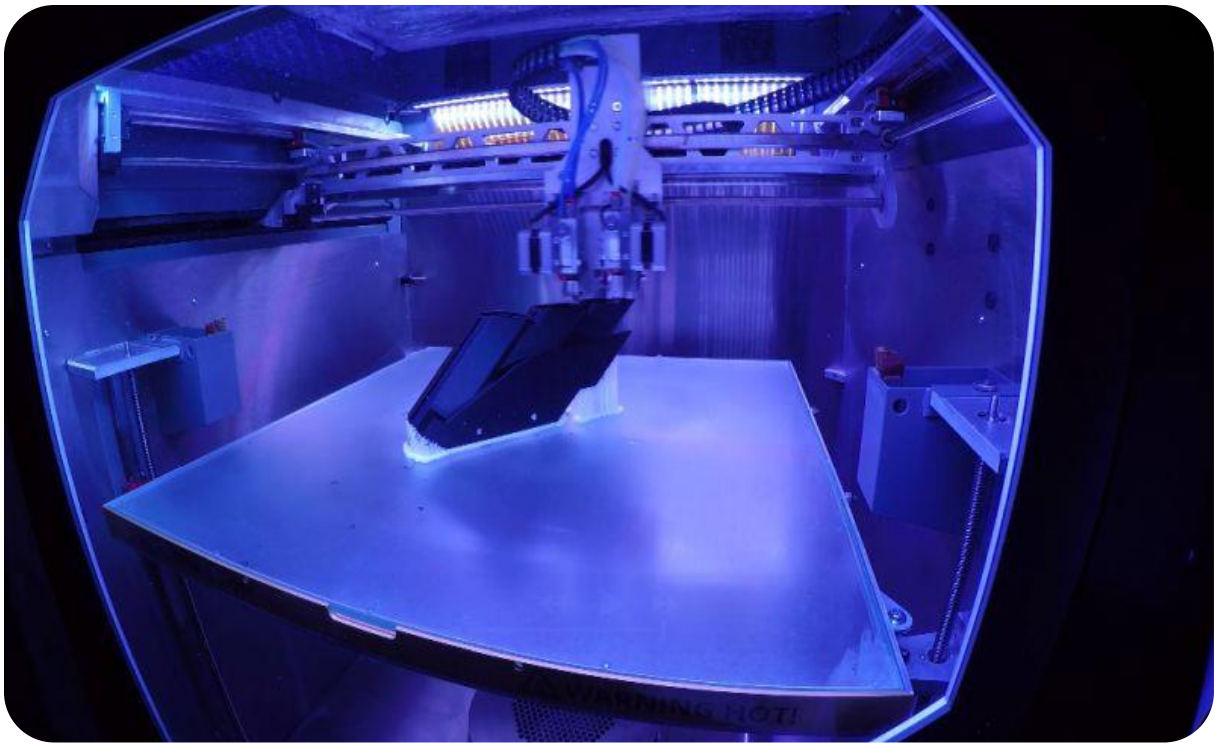

Fig. 2. *Printing proces on a Factory 2.0 Production System.*

Arrinera light mounts have been printed using the ABS-42 filament on the 3D Factory 2.0 Production System in FFF technology. The OMNI3D printer has an enclosed and heated chamber that allows you to produce the highest quality prints from the most durable polymers – such as PA-6/66, ABS-42 or ASA-39. The following table describes the 3D print specification.

Filament	ABS-42
Print time	10,5 h
Print layer	0,2 mm
Dimensions of the model	230 x 160 x 80 mm
Weight	165 g

Table 1. *Detailed 3D print data.*

3D scanning process

The 3D prints are susceptible to shrinkage. That may affect the geometry of an object. Fortunately, 3D technologies are a set of mutually compatible solutions. The 3D scanning using a measurement based on structural light perfectly supplements additive manufacturing. It allows the user to verify the quality of 3D prints. Only the best 3D printers are able to produce the automotive part capable of undergoing a stringent quality control.

The professional industrial 3D scanner – SMARTTECH MICRON3D green 10 MPix – was used for the measurement process. The optical measurement technology used by the device displays the stripes on the surface of the object. The stripes deform depending on the object's curvature, which is recorded by the detector built into the 3D scanner. During the measurement process the image from the detector is transformed into a point cloud. Each point is a geometric information described by the X, Y, Z coordinates that can be used in quality control.

Fig. 3. *MICRON3D green 3D scanner while measuring the mountings.*

The MICRON3D green uses a green LED light technology that achieves 30% better results than when using white light. With a volume of 400 x 300 x 240 mm the SMARTTECH optical measuring system acquires a cloud of points representing an object with an accuracy of 0.042 mm. This solution allows to accurately measure an object with a complex shape. The operator can be sure that the measurement error of SMARTTECH 3D scanners does not exceed the values given in the certificate of accuracy of the device.

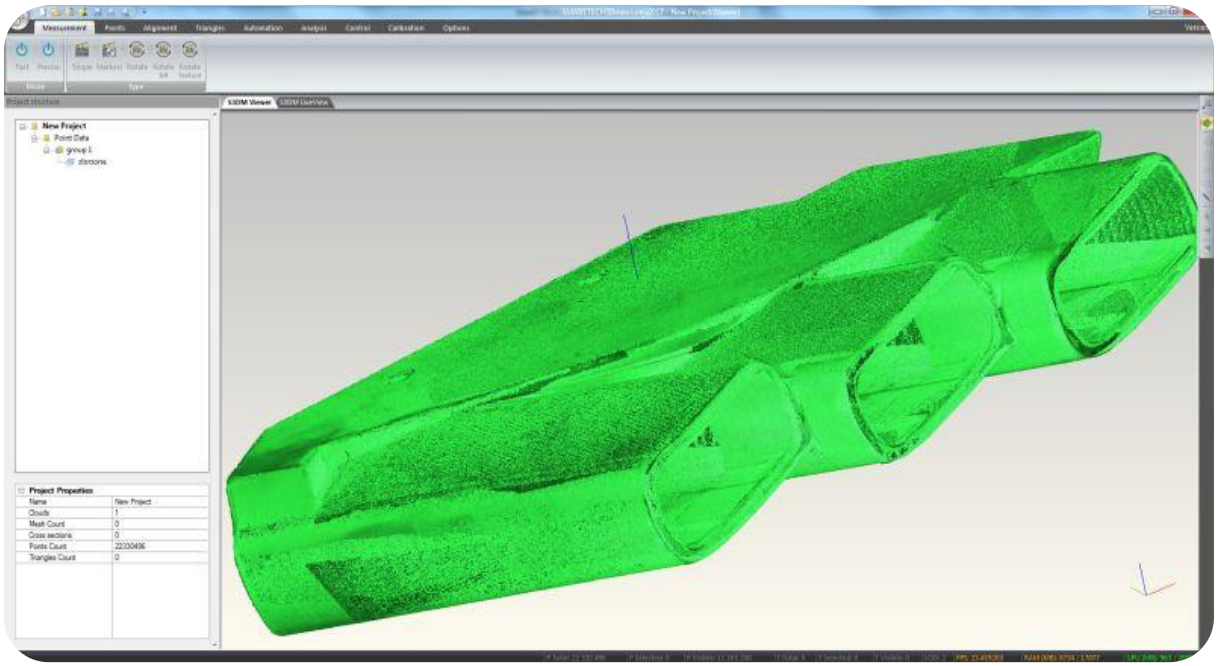

Fig. 4. *Dense points cloud representing the scanned object in SMARTTECH3Dmeasure.*

It is thanks to the scanner's permanent calibration and certification according to the German VDI/VDE 2634 guidelines. Additionally, the integration of the SMARTTECH 3D scanner with a

rotary table allows single measurements to automatically align. This function makes the object ready for quality control.

Quality control

The inspection was performed in the Geomagic Control software. This program has many functions such as creation of cross section, dimensioning, thickness verification and more. For the part printed by OMNI3D the dimensional quality control was performed using a reference CAD model and the measurement result. The operation enabled us to create a deviation map with point information on deviations. Engineers accepted a tolerance of 0.3 mm.

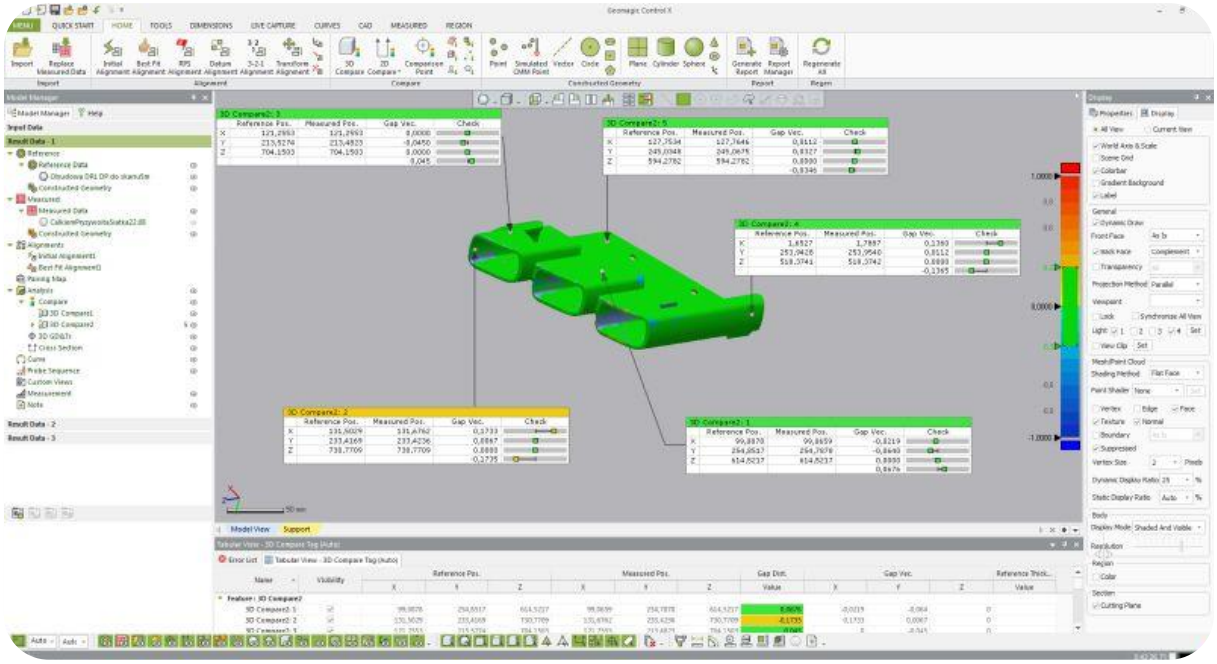

Fig. 5. *Optical inspection result in Geomagic Control.*

Despite the strict tolerance criteria the inspection shown that the print fit the assumed tolerance of 0.3 mm. The entire operation allowed the creation of a deviation map with point deviation information. The most extreme point representing the material shortage used 78,6% of the assumed tolerance. For the opposite point (material excess) the value was 61.8%. This means that the precision of the 3D printed part has been 30% better than expected. What is more, the average of all deviations was -0.033 mm. The average material shortage was equal to -0.133 mm, while the average material excess was 0.112 mm.

The table below presents detailed data about deviations between the reference model and the 3D scanning result.

	Sample reference points			Sample measurement points			Diff.	Toler.
	X	Y	Z	X	Y	Z		
#1	99,0878	254,8517	614,5217	99,0659	254,7878	614,5217	0,0676	±0,3
#2	121,2553	213,5274	704,1503	121,2553	213,4823	704,1503	0,045	±0,3
#3	1,6527	253,9428	518,3741	1,7887	253,954	518,3742	-0,1365	±0,3
#4	127,7534	245,0348	594,2782	127,7646	245,0675	594,2782	-0,0346	±0,3
Min.	1,6527	213,5274	518,3741	1,7887	213,4823	518,3742	-0,1365	
Max.	127,7534	254,8517	704,1503	127,7646	254,7878	704,1503	0,0676	

Table 2. *Detailed 3D measurement results.*

There is no technical possibility of making a part that perfectly represents the reference model, regardless of whether additive manufacturing, casting methods or injection molds are used. Each manufacturing method has different dimensional tolerances, so engineers adjust the tolerance taking into account the specificity of the manufacturing technology. In this case the optical quality control is needed as it verifies that the manufactured item is within the standards accepted by the engineer.

The precise data obtained by MICRON3D green 10 MPix indicates that the printed mounts of Hussarya 33 front lamp meets the tolerance.

OMNI3D

Polish manufacturer of industrial 3D printers in the FFF technology (fused filament fabrication). The company offers consulting services for implementing 3D printing technology in industry, as well as maintenance and 3D printing on demand.

Read more at www.omni3d.com

SMARTTECH

Polish manufacturer of professional optical measurement devices. The company successively develops its equipment and provides top level metrology solutions both for the industry as well as for education, museology or medicine.

Read more at www.smarttech3dscanner.com

ARRINERA

The first Polish supercar was built by the company Arrinera Automotive. The name Hussarya refers to the Polish cavalry from the XVII century. Arrinera was first introduced in the current form in 2008.

Read more at www.arrinera.com