3D digitalization of your product to simulate its behaviour

Capturing the entire real object surface opens up a completely new dimension in the quality and detail of the information you get about your processes. Optical 3D metrology and in particular SLS systems (Structured Light System) give today the possibility to measure and virtualize accurately the real part in a very detailed way. In order to minimize the Time to Market and increase the quality of the production process, the 3D digitalization offers from one side, for your prototype, a full description of the part to better find out the adjustments needed, from the other side, for the final product, an accurate measurement of your critical dimension and keeps your process under control.

This is the main field of application of Optical 3D metrology but not the only one. The complexity of numerical simulation is growing due to the need for real object geometry to be used as the input for the simulation task. In this case CFD, FEM-Mechanical or Process simulations (e.g. racing application, deformation analysis, injection moulding design, Casting process optimization) are someone of the most interesting new applications of 3D digitizing where the simulation of the real part, and not the theoretic one, allows us to reach the target in a precise and effective way.

There are three fields of integration between 3D scanning technologies and the virtual simulation.

- In the design step, the theoretical CAD model represents the only one starting point to optimize the shape and performance, while the 3D scanning of the real model becomes the only solution in the absence of CAD models or in case of modifications of the prototype.
- During the production step, the systematic measures of the products highlight the deviation, allowing the study of the impact of these "imperfections", that are detected statically, in the behaviour by simulation with appropriate CAE tools, by establishing the acceptable tolerances on the real products.
- The third field of integration, 3D Scanning- CAE, is the comparison between the deformed measured and the simulated

QFP®
DIGITIZING
ENGINEERING
INSPECTION

Fig.1 - Evolution of the elementary geometries to complex form and shapes

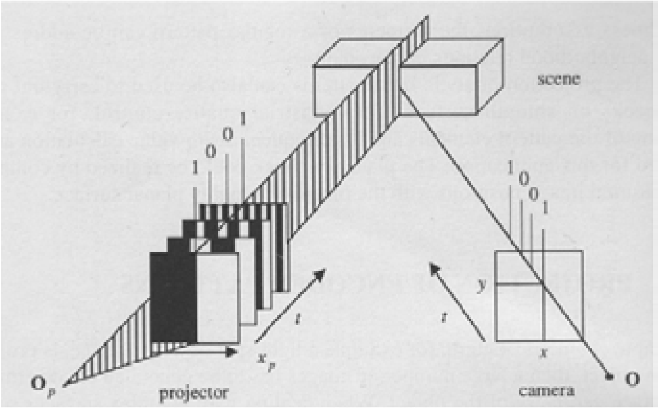


Fig. 2 - Diagram of operation of SLS systems (Structured Light System)

at the end of the production process (residual deformations of the individual component or assembled) or during the usage of the product (deformation under load in operation).

Introduction in the 3D Scanning

Today, design is the key strength of the products that surround us. Their functionality has become almost secondary, or taken for granted, as very often is the aesthetics to certify the success or failure. This constant research of style has transformed the products, composed of simple geometric shapes, into creations of depicting geometries and complex shapes.

In this way the project manager and industrial designer has become modern artists from one side, from the other side this implicates the necessity to transform and adapt the production processes in order to realize that ideas.

In this context, the optical 3D technology, and in particular the SLS systems (Structured Light System), that was for a long time a bleeding edge technology, has seen in recent years a huge success.

Since 2002 QFP has introduced nationally and internationally new technologies in metrology and process control, integrating them in different production processes.

In particular, the non-contact optical technology, commonly named 3D scanning, has seen an exponential growth in its use and in its progress in the last twenty years.

This technology provides new, highly versatile possibilities. Capturing the entire object surface opens up a completely new dimension in the quality and detail of the information you get about your processes. Whether you work with classical nominal-actual comparisons, speed up your form finding process for the capture of design samples, or use reverse engineering to create a parameterized CAD file allowing the digital representation of "old" components for which no CAD data is available (anymore) – optical measurement technology moves your business forward in many ways.

The first scanner 3D for industrial uses dated back about thirty years ago and was created with mechanical projection technology. The progress in electronic, optical and computer technology has allowed the transformation of these machines and today we have DLP projectors, optical calibrated and dedicated high-speed cameras to capture millions of points, with an accuracy level that was unimaginable thirty years ago.

A projection unit projects a fringe pattern, which is encoded using a special process onto the object to be measured. The topography of the object causes deformations and deflections in the fringe pattern. These make the object's surface visible to the camera systems (one or more cameras) in 3D, which form the second key part of a white light fringe scanner. To determine the individual 3D point coordinates, a triangulation calculation (relationships in the right-angled triangle) is performed from each camera pixel based on beam intersection (projector – camera(s)) and encoding.

Depending on the camera resolution and measurement volume that are used, a coarser or finer 3D point pattern (resolution) is placed over the object. The finer the pattern, the better intricate details (radii, edges, etc.) can be represented. This so-called lateral point spacing typically ranges between 20 μm and 250 μm, depending on the selected system.

In the automotive sector there was a need to accelerate and improve the process of reverse engineering in the field of style modelling with the scanning of the resin model or mock up. This has led today to the affirmation of CAD-CAM solutions that revolutionize the process. Since in the past there was only one time consuming solution through surface modelling in CAD, now it is possible to produce perfectly consistent surfaces for freeform area of the scanned model, parametric and regularized 3D geometry on the regular area or directly triangular mesh properly prepared to give place directly to the milling process, without having to go through surface modelling.

However, it is not thanks to the reverse engineering that today these machines are advanced and widespread technology, but rather their growth and acceptance in metrology.

Their use today covers a usage in different sectors and at different stages of the production process.

In automotive, aerospace, energy, industrial design today the first article inspection using this technology reduces the time to marke t and the process control allows to implement programs of quality management (Six Sigma), driven by growth in the rate of control.

A 'new' and interesting field of application for the data generated from these systems is also represented by virtual experimentation or simulation.

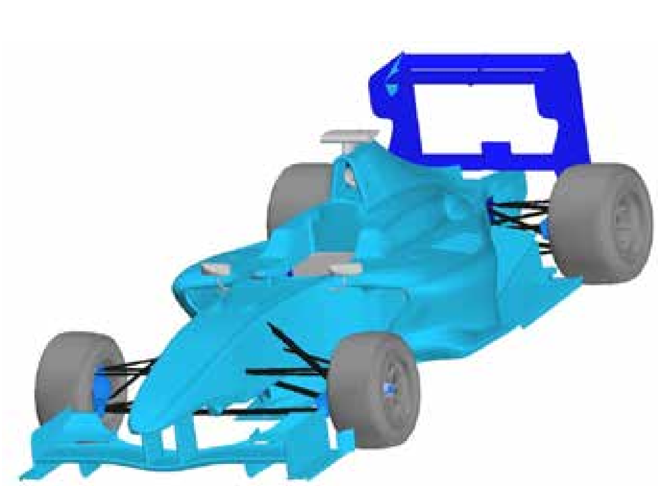
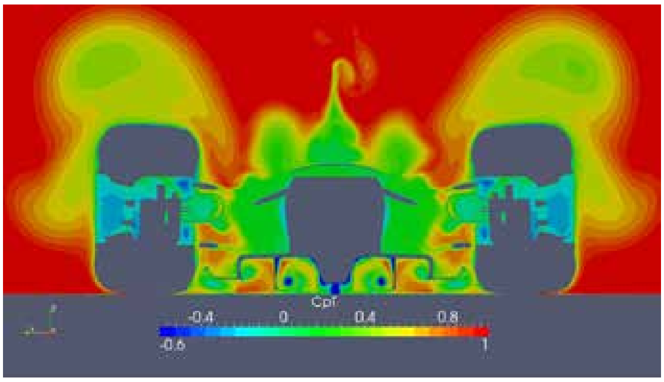
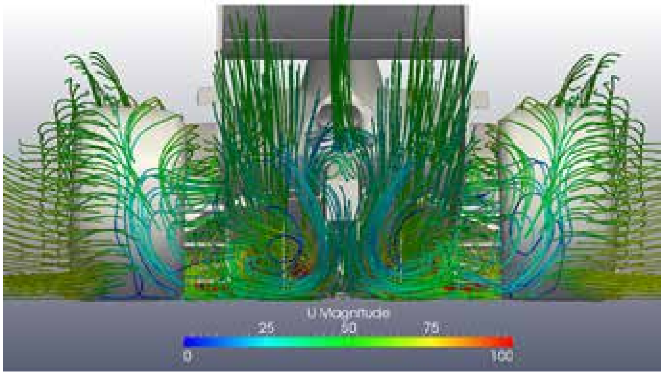


Fig. 3 - 3D digitalization of the GP3 car from nosetip to rear edge of rear endplate





In fact, the 3D scanning enables in the first place to capture and virtualize the real geometry and therefore offers the opportunity to present in the simulation the real figure and not the theoretical one. The type of production process and the way in which this is implemented and parameterized determines, for the single component, the level of the deviation between theoretical data and actual data.

An object that is composed of n components presents in the final assembled the sum of the inaccuracies of the individual components. All this is well known and carefully assessed, as a rule, during design and product development. However, as analysed and evaluated, it will result in each case a difference between the theoretical and the real 3D.

CFD - AERO - FLUID DYNAMIC ANALYSIS OF BEHAVIOUR

In some sectors, more than in others, to know this difference can mean winning or losing a challenge. In the world of racing, for example, it becomes a fundamental tool in order to analyse the real aerodynamic behaviour of the car. Here, where everything is taken to the limit, it is extremely important to know the real geometry, that goes wet from the air, because it means to know how to optimize the behaviour of the car in the race.

Projects developed on cars for GP2, GP3, F3, Inshore boats for competitions as well as the optimization project of the handbike of Alex Zanardi, brought noticeable benefits to simulate the real object.

For example for the car GP3, it was possible to make a development of aerodynamic solutions through CFD analysis of the complete 3D survey of the car itself.

The triangular surface mesh captured with scanning and allowed to introduce in the simulator CFDs the actual geometry of the vehicle. This starting point is a very important and a fundamental for the result, because it has been found that the differences between the theoretical model and the real were important.

Another fundamental aspect to obtain a CFD simulation, that is very adherent to the real behaviour of the car, which has been made possible using specific scanning equipment, was the possibility to dispose for the simulation of particular available only through the 3D relief. The Comet 5 11M, a scanning system with fringes projection by 11 megapixel, has in fact enabled, with its 11 millions of points for shooting, to capture 'imperfections' on the surface as for example the weave of the composites, the rivets, the coupling profiles (flush and gap).

This information is very important and decisive to develop aerodynamic solutions of winning in the various conditions of loading and trim.

The simulation of the real figure represents a path to be made where the product does not meet expectations in terms of performance or behaviour.

3D scanning of a hull of 45mt made it possible to have a dimensional control first, then the CFD simulation, identifying the reasons for which the boat could not reach the expectations of speed.

Always through the 3D scanning of some 'equal' hulls of 18 feet, it was possible to identify the reasons for which these hulls showed different behaviours in terms of drivability.

TESTING

In the automotive industry, testing laboratories, through crash tests or tests destructive impact, with rigorous methodologies established by guideline, occur and classify today's levels of vehicle safety.

3D scanning in this area is the tool adopted to validate the simulation model of deformation in comparison to the deformation undergone by the real component (and precisely detected by 3D scanning), as well as the tool used to measure the actual deformation of the vehicle in the tests d'impact for certification.

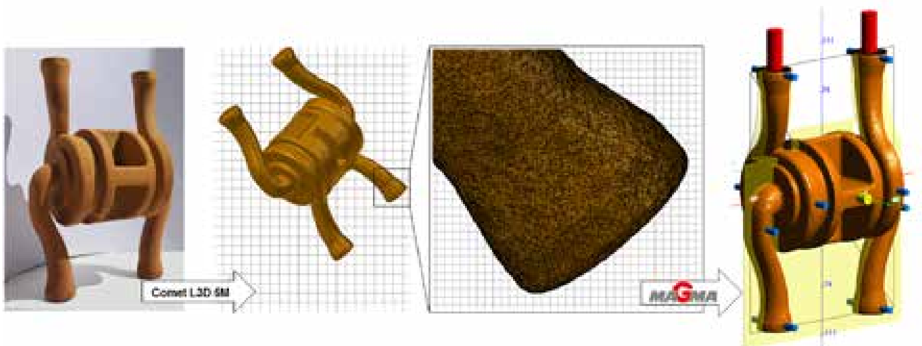


Fig. CM 1 – Definition of the virtual model from 3D scanning

SIMULATION IN THE PRODUCTION PROCESS

Casting simulation in the field of foundry, die casting, plastic moulding is validated by the conformity of the simulation to the real object detected.

In fact, it is necessary to set a loop where the 3D scan allows to measure through a dimensional control the effects of the simulation on the product actually made and to refine inversely the process parameter.

In some cases, however, 3D scanning can be the starting point to study the production process with reverse engineering for the realisation of the equipment needed for production.

The detailed scan of the actual object makes it possible to reveal the technology, the technique and the location of the equipment used for its production. In foundry, for example, with Comet L3D 5M it is possible to reconstruct the path that led to its production, starting from the core and optimizing the process based on the findings on the actual product.

MAGMA is a world- wide leading developer and supplier of software for casting process simulation. As a powerful simulation tool, MAGMA C+M turns core production into a calculable and optimizable activity. Core shooting, core curing and the thermal control of core boxes can be analysed to find the best solution.

MAGMA C+M supports core and mould manufacturers by offering process transparency, feasibility evaluation and rapid construction of core shooting tools.

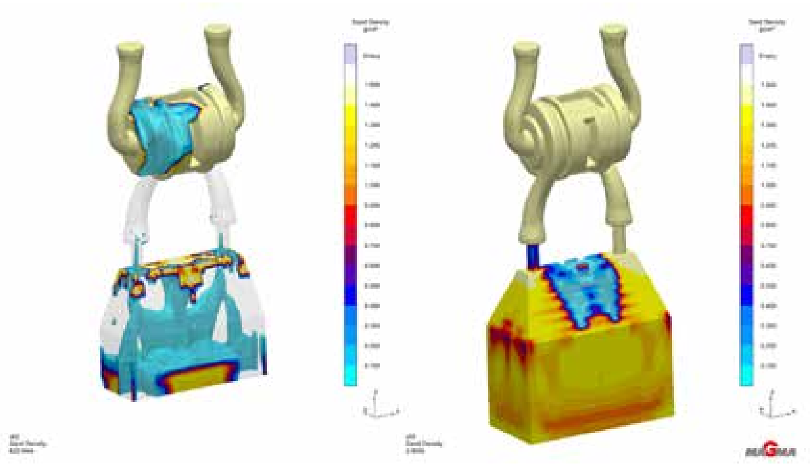


Fig. CM 2 - Shooting tests with shoot head from bottom

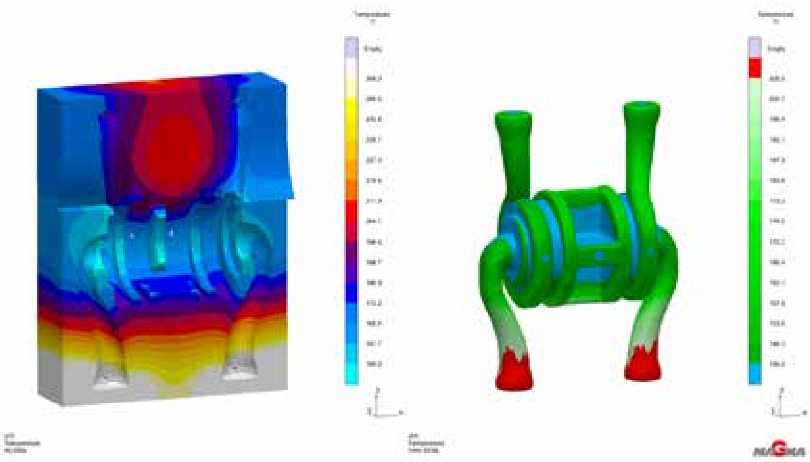


Fig. CM 3 – Temperature distributions on the core box and core curing

The software is a design tool that allows to simulate the automatic moulding of foundry cores fully, from the shooting to the curing phase according to the various technologies available today. It offers an easy way to expand the knowledge of the process making it transparent. It was therefore possible to import directly the scanning of a core into the three-dimensional modeller MAGMA5 and define the configuration of shooting and curing directly on the imported geometry (Figure CM1)

With version 5.3 the optimizer is integrated into the standard simulation environment of MAGMA5, so it is possible to vary the process parameters and evaluate the consequent effects on the final quality of the product, in an easy way.

Trying some typical configuration for the chosen binder technology (Croning -Shell Moulding) the process parameters that allow to produce the core, both for shooting and subsequent curing, was traced automatically.

It was therefore possible to understand the great importance of the shape of the shoot head from bottom on the filling of the cavity at the same shootting pressure (Figure CM2), as well as identify the causes of the burns observed on the scanned sample in function of the position and power of the heaters that control the temperature of the core box.

CONCLUSIONS

Virtual experimentation today is an irreplaceable and sometimes essential tool for industry as it allows us to:

- reduce the "time to market"
- improve products through quick comparison with alternative solutions
- build a network with subcontractors, possible through the simulation path, that allows you to experiment in a single project also just sequential stages, joining then at the end all the specific skills
- start the design according to the logic of "concurrent engineering"
- share the product with the customers and also the stages of their realization
- optimizing the production process, minimizing the risks of erroneous technical choices and avoiding neglecting aspects that could have significant impact in terms of cost and time
- enhance and develop their design know-how

In these situations, the 3D scanning allows to validate the simulation model through the measure of reality, of the real object.

Andrea Pasqualetto, QFP

For more information:
Nicola Gramegna, EnginSoft - n.gramegna@enginsoft.it