Design Model Completed

Digitizing a clay model with the Steinbichler COMET 3D sensor system and preparing the data for milling with the PolyWorks® software

The task

When a new vehicle is designed, different ideas of shapes, features and characteristic lines are realized – first into drawings and renderings, and then into a 3D model. The design takes shape as a three-dimensional clay model. For this, a special modeling clay is applied to a wooden base frame and can then be shaped by hand using different tools, which is a complex and time-consuming process. The clay models serve as prototypes to allow precisely defining the shape of the body shell of a new car. In addition, they are used for the first aerodynamic tests. As the time available for developing new products – and vehicles in particular – becomes shorter and shorter, new ways need to be found to accelerate the creation of prototypes in the design process.

Computer-aided styling (CAS), the virtual development process in designing, increasingly supplements classical form finding. In cooperation with Prof. Dr. Wickenheiser of the Transportation Design course at the Munich University of Applied Sciences, in cooperation with Steinbichler Optotechnik GmbH and kindly supported by Rücker GmbH, the Duwe-3d AG created a full three-dimensional prototype by 3D digitizing a clay model and processing the measured data in the PolyWorks software. This eliminated the need to complete the entire clay model by hand. 3D digitizing and mirroring the half model allowed milling a completely symmetrical model from lightweight Ureol blocks. The milled model was then primed and painted. The stored 3D data set can not only be used for archiving and documenting previous design ideas, but also offers the possibility to reproduce and scale the prototype at any time.

Fig.: A projector illuminates the measured object with patterns composed of parallel fringes of different widths and intensities.

Digitizing

The clay model was digitized using the COMET 5 11M, a fringe projection system from Steinbichler Optotechnik GmbH. A fringe projection sensor consists of a pattern projector, which basically resembles a slide projector or beamer, and one or more digital cameras. The projector successively illuminates the measured object with patterns composed of parallel fringes of different widths and intensities. The camera records the projected fringe pattern from a known angle to the projection, and can calculate 3D coordinates for all captured image points from the many single images. This principle of 3D scanning can be employed in a vast variety of application areas because it allows covering measurement volumes from several meters to just a few centimeters. This has the advantage that the resolution can be refined to within the micrometer range. To fully capture the clay model, digitizing was performed from different views. The data acquired in the individual digitizing operations was combined to one point cloud by mathematical methods. This point cloud is the basis for processing the data in the PolyWorks software.

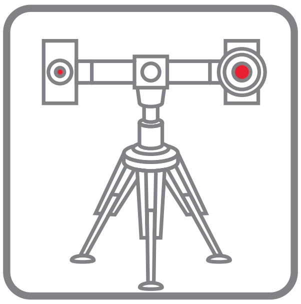


Fig.: The clay model is captured from different views by the Steinbichler COMET 5 system.

Data processing

The 3D data (point clouds) is imported into the PolyWorks software. Now a closed surface of the captured object is to be generated from the point cloud. Using triangulation, the points are converted to triangles and a polygon mesh is calculated. In PolyWorks, it only takes a push of a button to quickly and easily generate, smooth and filter polygon meshes from point clouds comprising millions of points. Any remaining gaps in the polygon mesh can then be filled. Component edges that were imprecisely captured during digitizing can also be reconstructed as sharp edges in PolyWorks.

In this project, the polygon mesh of the half vehicle was mirrored to generate a symmetrical prototype from the half model. The finished polygon mesh provides the optimum basis for the actual reverse engineering process.

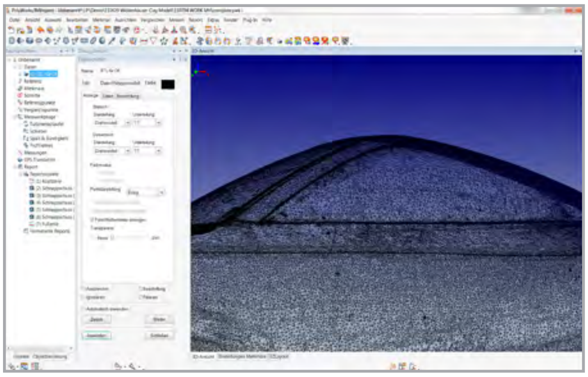


Fig.: In PolyWorks, closed triangle meshes are calculated from the point clouds.

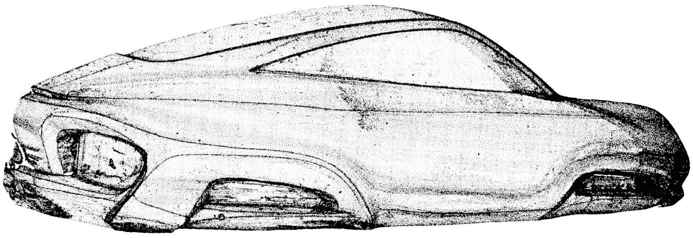


Fig.: Representation of the captured point cloud in PolyWorks

Reverse engineering

Once the polygon mesh has been prepared, the actual reverse engineering process can start. Polygon meshes cannot be used directly for designing in CAD systems because no parametric information is available. For this reason, an additional step is required to generate millable NURBS surfaces from the polygon mesh.

The majority of work in creating CAD-compatible NURBS surfaces is to divide the polygon mesh into surface patches. Three-sided and four-sided surface patches are bounded by spline curves. After the surface patches have divided the entire structure of the polygon mesh into regions, they are fitted like skin over the acquired measurement data. The result of the fitted surface patches is the NURBS patches. All connected NURBS patches are also referred to as a NURBS model. This NURBS model can now be exported as an IGES or Step file to make it available in a millable CAD format.

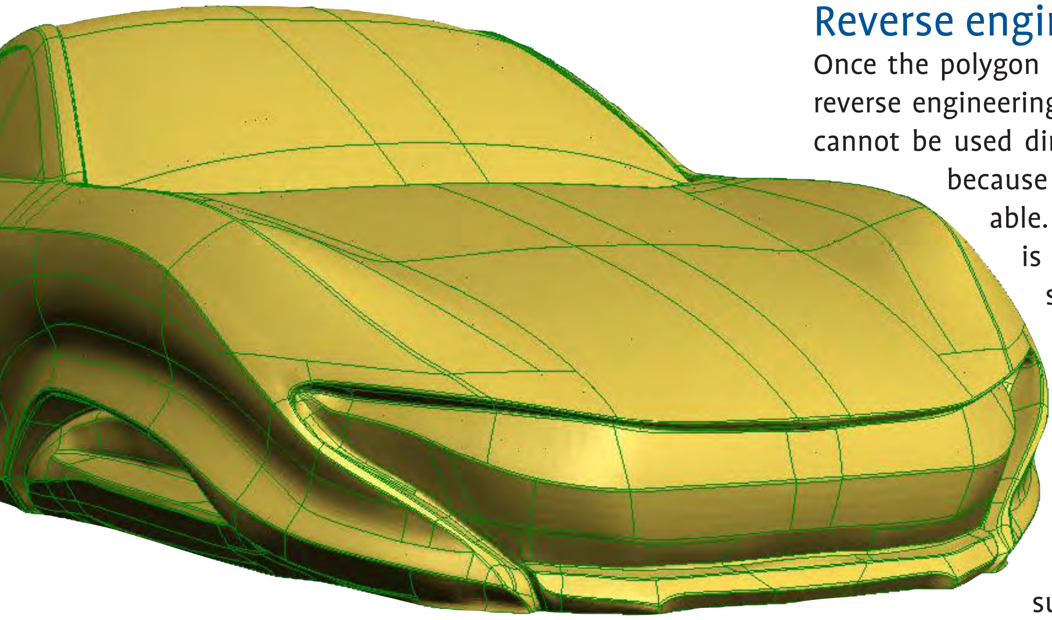
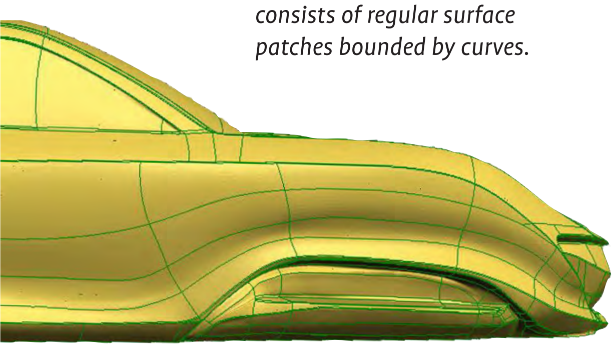


Fig.: The finished NURBS model consists of regular surface patches bounded by curves.



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From the data set to the real model

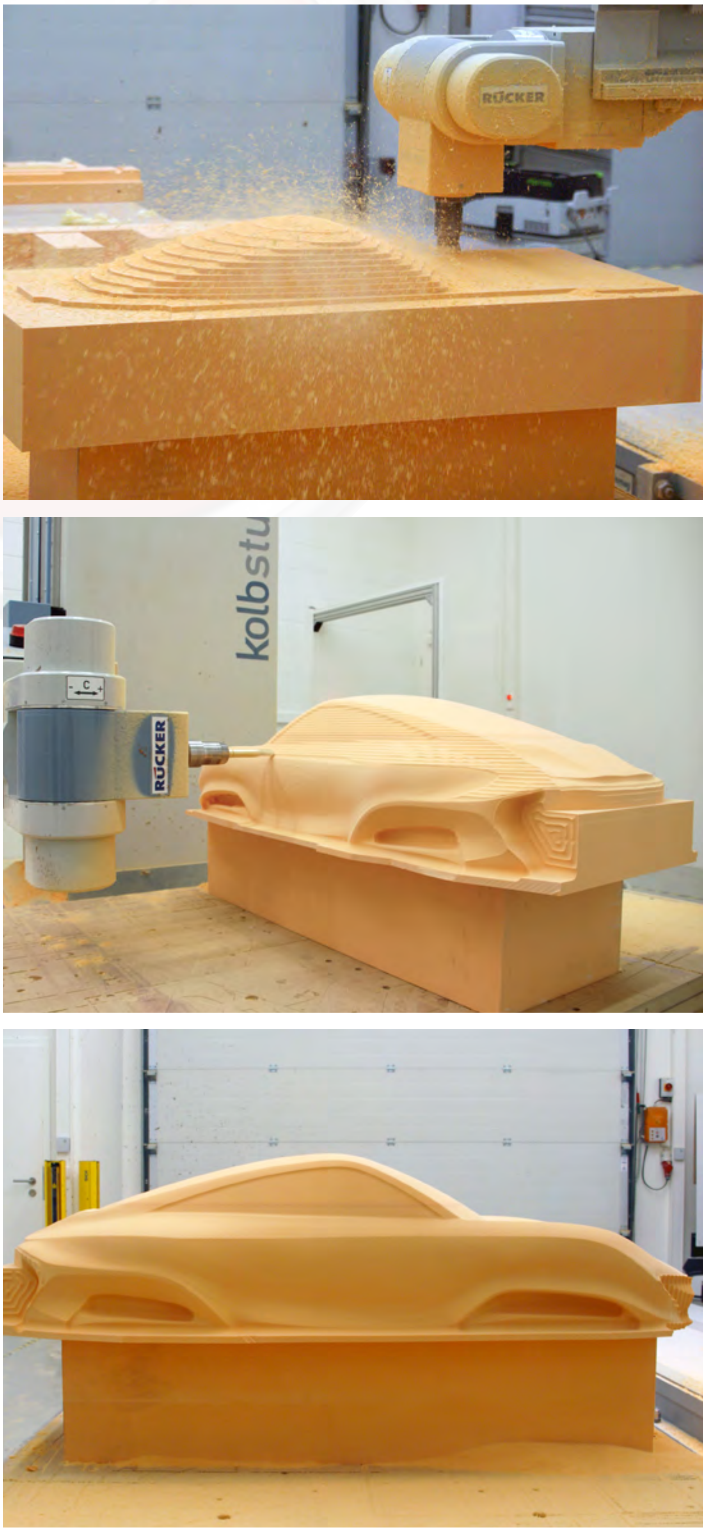

Fig.: The shape of the vehicle model is refined step by step in multiple milling passes.

To turn the virtual design model back into a real prototype, the processed data set was milled from Ureol material by the Rücker AG company in Böblingen, Germany. Ureol was chosen for its properties, which are ideal for use in industrial modeling. The material consists of a PU resin saturated with filler. This makes it light-weight and yet very hard-wearing. With its very fine structure, the material is also excellent for further refinement, i.e. honing and painting.

To produce our vehicle model, a 5-axis CNC milling machine was used. In CNC milling, the five axes and the paths of traverse of the milling machine are programmed with a machine control. The workpiece is machined line-by-line in many small, adjacent passes. A 5-axis milling machine can position and move the milling cutter at any angle to the workpiece, which allows producing extremely complex 3D contours. Milling heads of different sizes were used for our vehicle model. A rough model was milled first, and then refined step by step with every milling pass until a smooth surface was achieved. The finished Ureol model was then primed and painted to make it look like a “real” vehicle. In this way, a digital three-dimensional data set and a complete Ureol prototype were made from a clay half model in minimum time.

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www.design.hm.edu

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