Optical Digitizing by ATOS for Press Parts and Tools

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During recent years, optical sensors like the ATOS system for digitizing sheet metal parts and tools have been more and more used in the industry. Good interfaces to conventional CAD/CAM systems made such digitizing systems part of complex process chains. These process chains mainly focus on optimizing the development of products and production processes and on improving the product quality. Using optical digitizing systems considerably decreases the development time for products and production while improving the quality. Compared to tactile measuring systems, the typically complete measurement of components with optical systems, provide an important advantage particularly for complex geometries.
The following pages focus on the nominal/actual comparison of sheet metals used in the automotive industry for analysis and inspection purposes and on various applications in tool manufacturing.

1. Introduction

ATOS, an optical 3D digitizing system, measures the complete shape of parts. This technology is mainly used in the automotive industry in reverse engineering, analysis and quality control applications:

- First article inspection
- Assembly control
- Tool manufacturing and optimization
- Production monitoring and
- Incoming components inspection

The main advantages of this relatively new technology are:

- coverage and visualization of the complete parts in 3D as well as the comparison with CAD data
- fast measuring process in comparison with traditional touch probe based measuring systems like coordinate measuring machines
- high resolution and accuracy which exceed the demands in related applications and
- mobility of the system which allows the measurement of parts at different places.

The importance of that technology will further increase in the future as it improves the time compression of the part and its production development as well as shortens the feedback time of the production monitoring.

2. Optical 3D Digitizing; Principal

The ATOS system is based on the triangulation principle: The sensor unit projects different fringe patterns on the object to be measured and observes them with two cameras, **figure 1**. Based on the optical transformation equations, the computer automatically calculates the 3D coordinates for each camera pixel with high precision. Depending on the camera resolution, a point cloud of up to 4 million surface points results for each individual measurement.

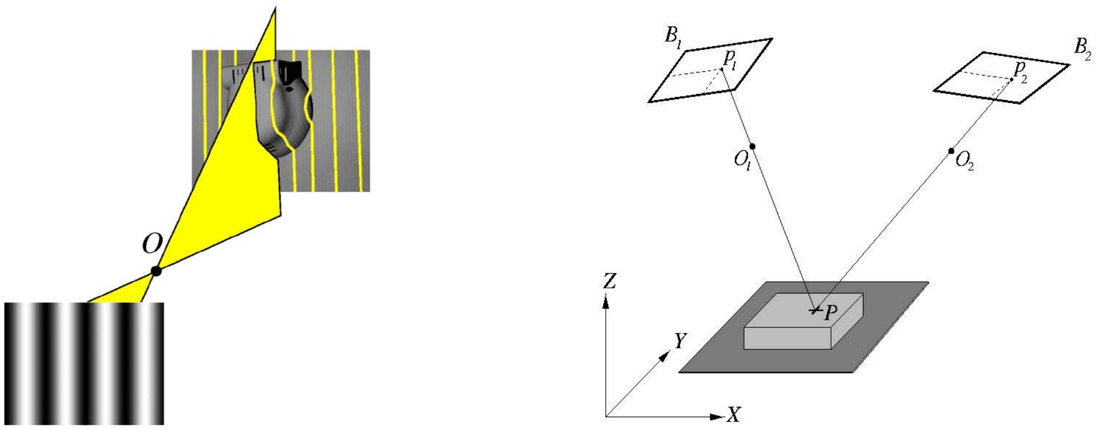

Figure 1: Fringe projection and triangulation

The projection unit and the cameras are integrated in the compact ATOS sensor head. The geometrical configuration of the system and the lens distortion parameters are calibrated using photogrammetric methods. The user then may position the sensor head on the stand in front of the part without additional handling technology needed, **figure 2**. Targets applied to the object itself or to the fixture serve as reference points for the scanner.

Figure 2: Handling of the ATOS scanner

In order to completely digitize an object, several individual measurements from various views are required. Transformation into a global coordinate system is done automatically by means of the reference points. The user can observe the digitization progress continuously on the screen. Each individual measurement completes the building-up of the 3D model of the object to be scanned. Finally, at the end of the digitizing process, a high-resolution polygon mesh of the surface completely describes the object. Generally, this mesh is thinned curvature-based in order to reduce data. In addition, feature holes and the border line of the sheet metal are displayed, **figure 3**.

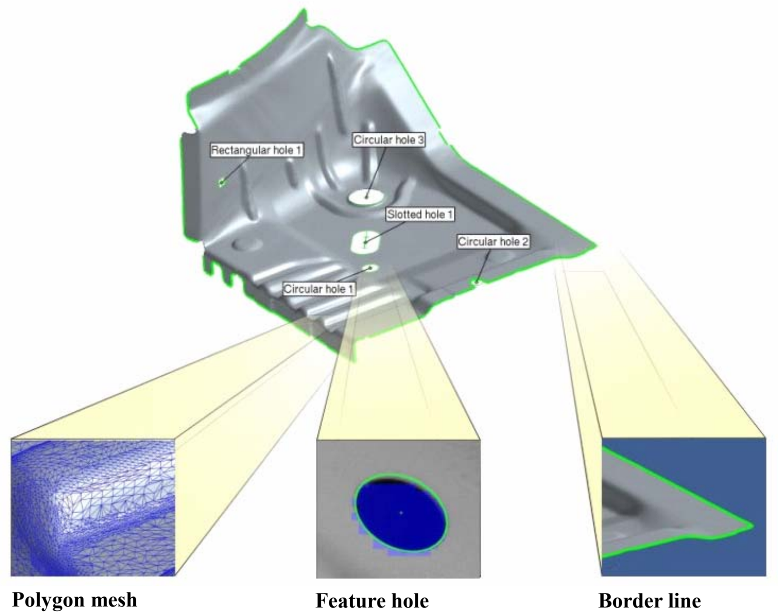

Figure 3: Digitization result

For larger objects like car bodies, side panels or larger forming tools, reference points are applied directly to the object. Prior to the actual scanning process, these reference points are measured by means of the photogrammetry system TRITOP. For this purpose, the object is recorded from various views using a digital reflex camera, **figure 4**. TRITOP provides for creating a reference data set for objects of almost any size. For an object of 4 meters, the 3D accuracy is approximately 0.1 mm.

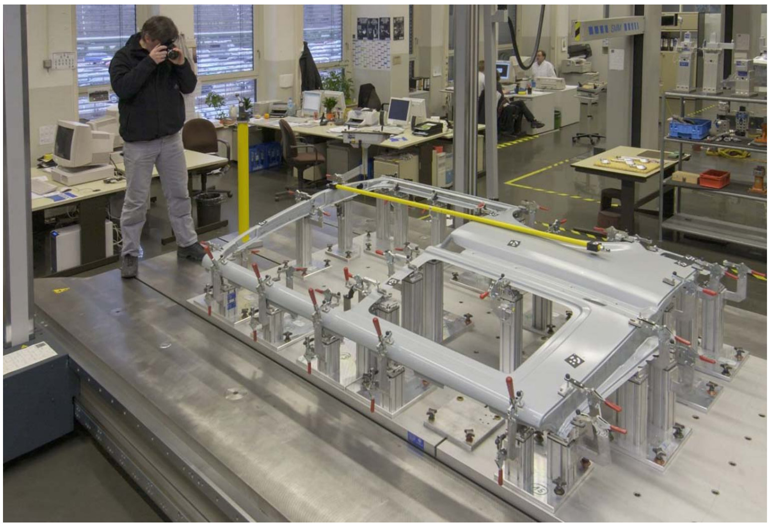

Figure 4: Creating a reference data set of a side panel with TRITOP

3. 3D Digitizing in Verification of Pressed Parts

The analysis and inspection of sheet metal parts using the ATOS system provide a considerable potential for optimizing products and production procedures, particularly for the automotive industry and its suppliers.

First, the sheet metals are digitized as described in section 2. Then, the measured data are aligned to the CAD model. Generally, this alignment is based on characteristic points like circular holes, slotted holes, edge points or surface areas, the specifications of which are given by an RPS system (Reference Point System). These specifications are either taken from the product drawing or directly from the CAD file. **Figure 5** shows the alignment of the measuring data using such RPS points.

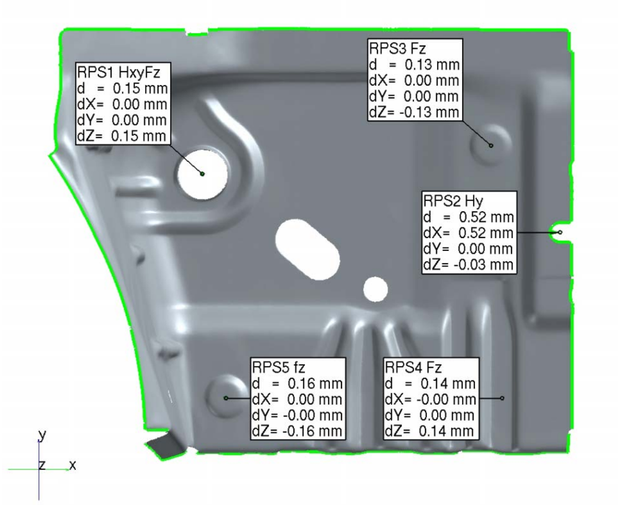

Figure 5: Alignment of measuring data to CAD data

After alignment, the deviation of each single measuring point is calculated with respect to the nominal contour. As the measuring points have a high density, the deviations can be visualized as surface color plots, **figure 6**. This representation allows a fast and accurate analysis of the object. These color plots are particularly suitable for the evaluation of the part during tool try-out, first article inspection and for measurements accompanying production as well as for a process check.

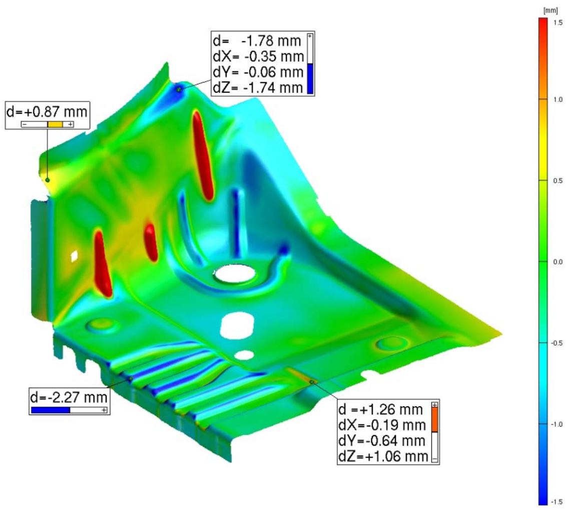

Figure 6: Color-coded deviation plot with annotations

In addition to the surface representation, the position of holes, slotted holes, border lines etc. can be determined. The deviation in space with respect to the nominal values can be displayed in form of labels or tables, **figure 7**. Frequently, tolerance values are specified which have to be complied with when comparing the nominal and the actual value.

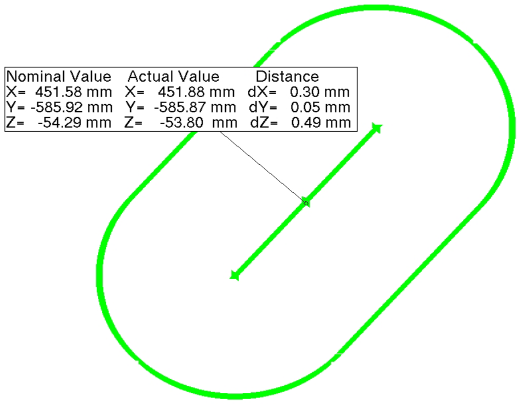

Figure 7: Position control of slotted hole

As the measured data completely describe the object, cross sections may be created at any position and compared to the nominal data. The deviations are visualized, for example, by the height of colored needles, **figure 8**.

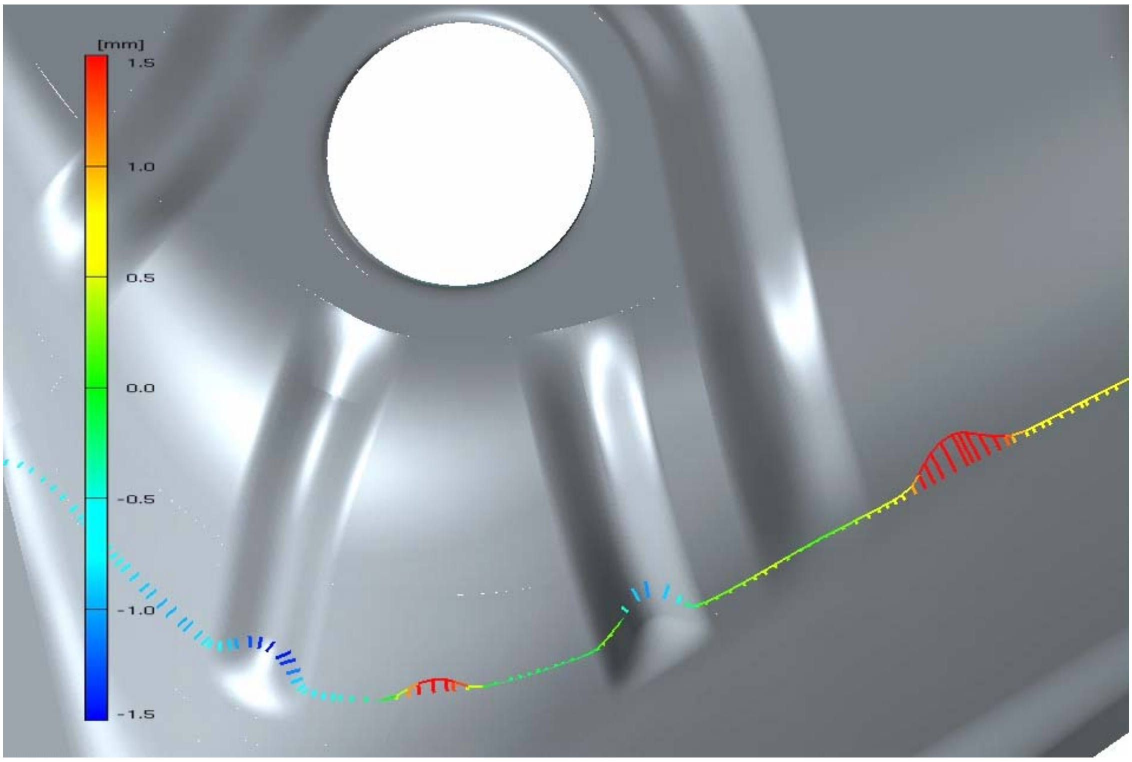

Figure 8: Cross section analysis

For repeated measuring tasks and for measuring identical or similar parts in connection with large quantities, the demand for automated measuring procedures and result evaluations increases more and more. For these applications, the ATOS control unit supports industrial robots and rotation tables. It is easy to install the ATOS sensor head to a commercial robot, **figure 9**.

The robot once is driven manually to the different views required to measure the object. A convenient interface in the ATOS software provides for saving the robot positions and integrating them into the respective measuring program. Without any further interaction required, this program can be run an arbitrary number of times.

A user-friendly macro recorder is available for automated evaluation of the measuring results. Using this macro recorder, the alignment, the definition of the measuring schedule, the configuration of measuring reports and evaluations are saved and made available for repeated measurements.

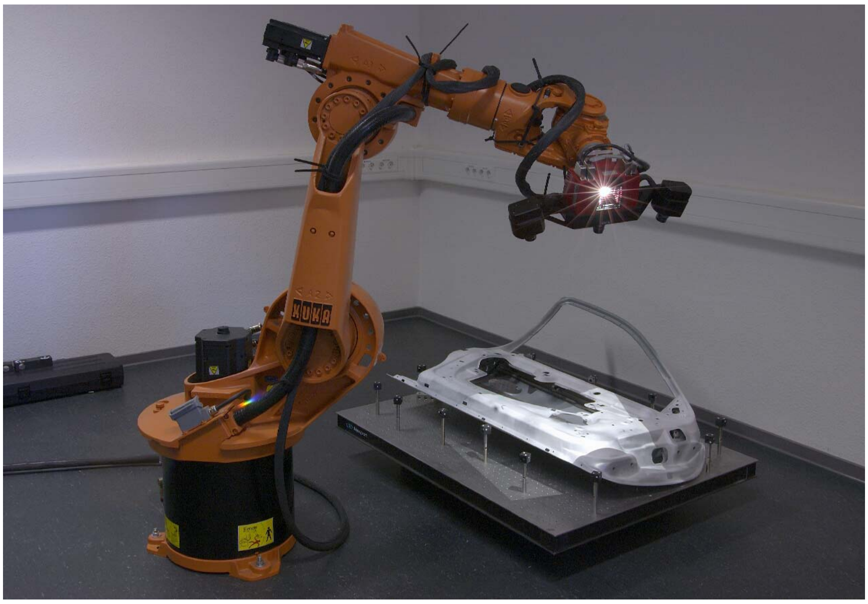

Figure 9: ATOS on a robot

4. 3D Digitizing in Tooling

In tooling, there are manifold tasks for digitizing with ATOS, like measuring cast blanks, measuring tools after try-out, copying tools by milling on the measured data.

4.1 Measuring blanks to optimize the milling strategy

Large tools for sheet metal forming are mainly produced from tailor-made cast blanks. The cast blank is oversized in order to compensate the tolerances of the mold and casting techniques. In addition, the active parts of the tool must have processing allowances such that the required shape and surface quality of the pressings and stampings can be achieved by milling, grinding and polishing at the effective areas of the tool.

Optical digitizing captures the real shape of the cast blank and allows for fast and complete allowance control. Using special lenses, the ATOS sensor head is adjusted to a very large measuring volume of approx. 2 x 2 m. Digitizing the complete shape of the cast blank is achieved by just a few measurements recorded from a few directions and is finished within half an hour, **figure 10**.

Figure 10: Fast measurement of a cast blank using the ATOS system with a large measuring volume.

The measuring data can be directly loaded into CAM systems like TEBIS or WorkNC as STL data (polygon mesh). Based on the digitized data, first the allowances are checked and then the optimum alignment of the blank with minimum processing time. In addition, the optimum milling paths, which provide for cutting the desired shape under optimum cutting conditions, are calculated based on the actual shape of the blank, **figure 11**. As the shape is available as complete and digital data set, modern milling programs can carry out a complete collision calculation, ensuring that the blank is processed safely, efficiently and without any crash or break of the cutter even without manual supervision.

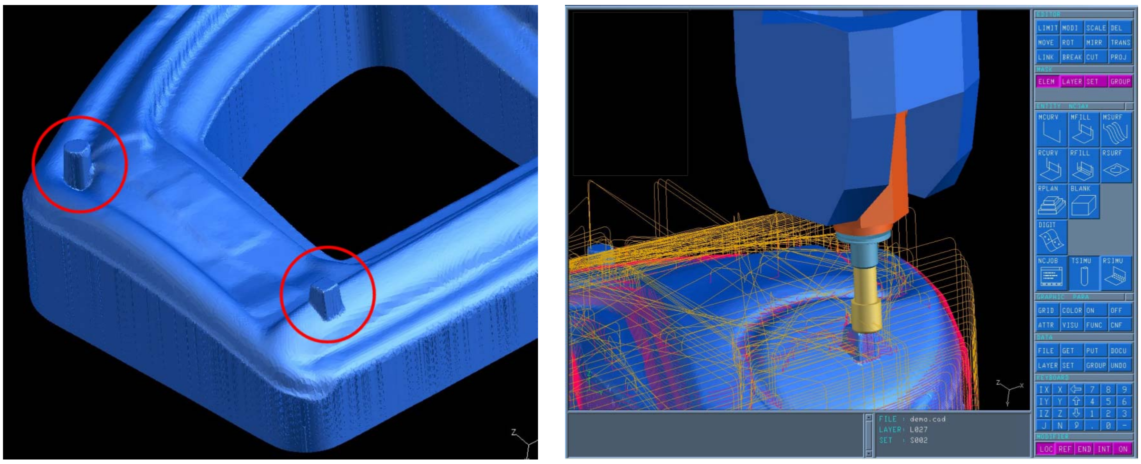

Figure 11: Digitized data and calculation of the optimum milling strategy.

The time for roughing a tool is reduced by an average of 50 percent when using optical digitization.

4.2 Measuring tool try-outs

Pressed sheet metal parts made with tools manufactured according to the CAD data, in most cases do not comply with the specified data straightaway although the deep drawing processes have been simulated in advance. Therefore, those tools have to be modified manually (try-out) resulting in the fact that the tools after the try-out process differ from the CAD data models.

Using optical digitizing, modified areas can be identified by means of a nominal/actual comparison, **figure 12**. Surface reconstruction of the relevant modified areas provide for updating the CAD to the real shape of the tool. Thus, if required, a substitute tool can be manufactured in no time, e.g. in case a tool breaks.

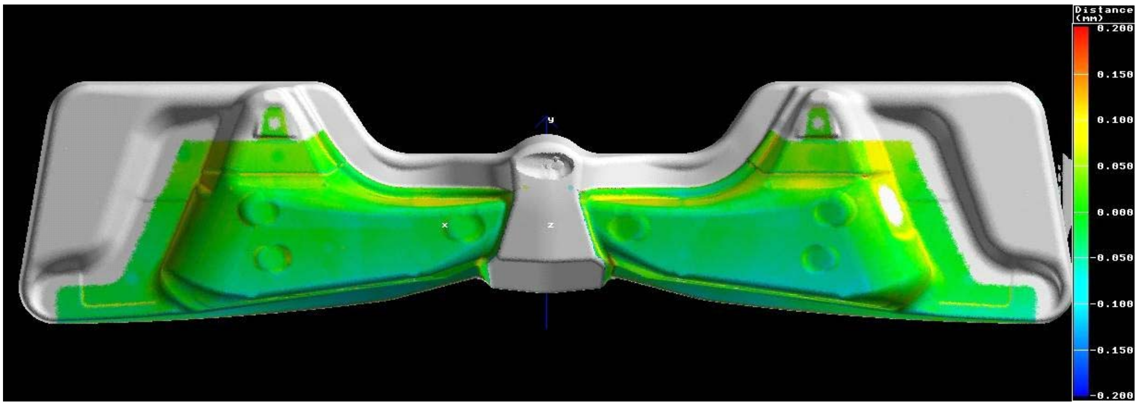

Figure 12: Nominal/actual comparison of the surface of the actual tool shape after try-out and the CAD data.

4.3 Milling on measurement data

For simply copying a tool or a modified area, the digitized data may also be imported as STL data into CAM systems without surface reconstruction. The high accuracy and the data quality of the ATOS system allows for direct milling on the polygon meshes with normal finishing work, **figure 13**.

Figure 13: Measuring data as polygon mesh and result of the milling process.

5. Conclusion

Optical digitizing using the ATOS measuring system is part of advanced process chains in the development of products and production processes for sheet metals and tools. Already today, time, costs and quality are optimized, thus increasing the competitiveness of companies.

In the future, this measuring technology will be used increasingly for automated inspection tasks due to its further integration in processes and the availability of powerful data processing systems.