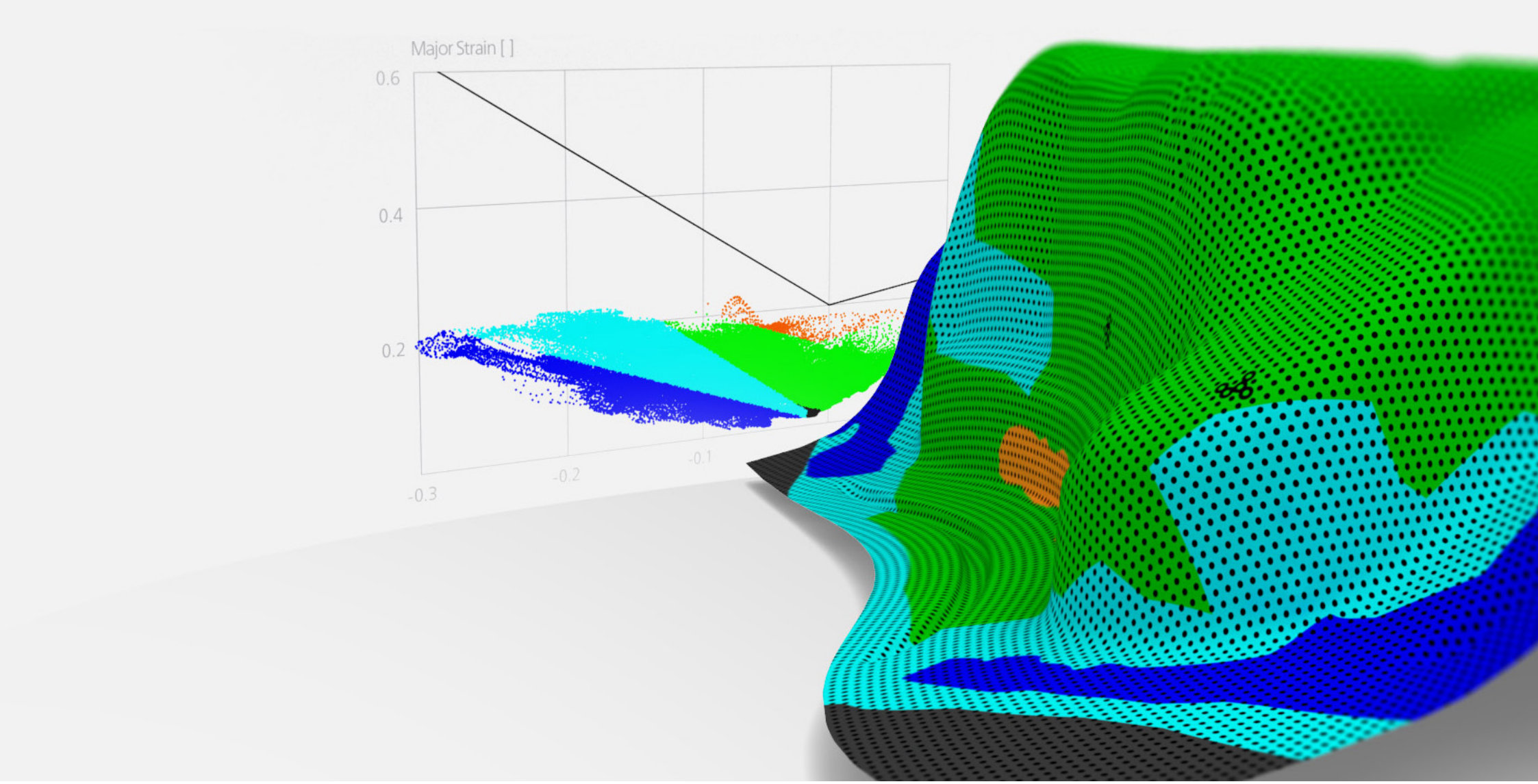


ARGUS

Optical Solution for Forming Analysis

ZEISS

Seeing beyond

ARGUS

Evaluation of Forming Processes and Simulation Validation

The optimization of the sheet metal forming process, taking into account the correct material selection and optimization of tools, is a decisive factor for competitiveness, particularly in the automotive industry during the development process of sheet metal parts, for tool try-out and in production troubleshooting.

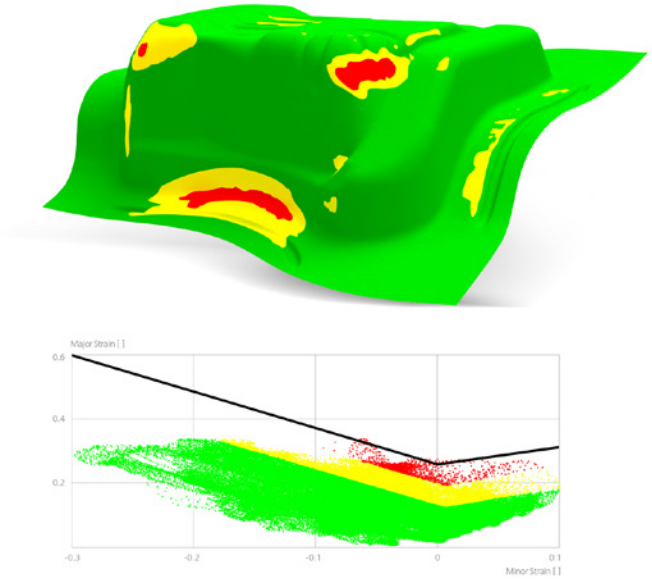
The forming analysis system ARGUS supports such optimization processes particularly by convincing and precise results of the surface strain on the components. The full-field results with high local image resolution provided by ARGUS enable the measurement of small and large components.

Forming Analysis

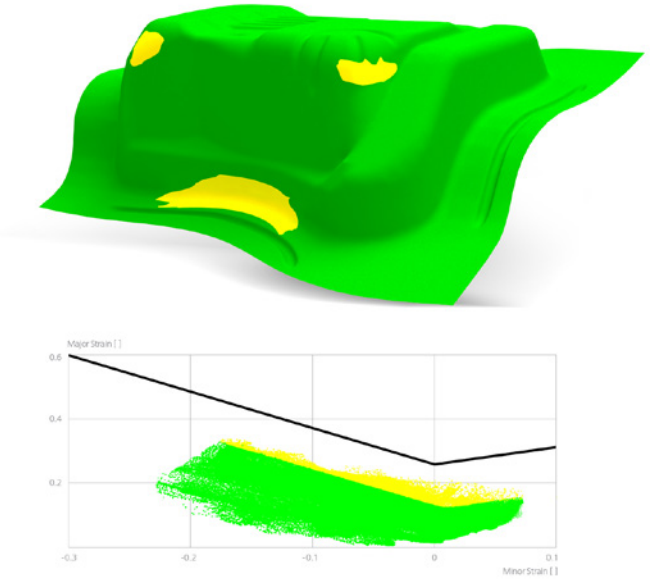
Forming analysis is a process to evaluate the forming states and surface strain levels of sheet metal parts after forming. The ARGUS system from ZEISS can be used to capture 3D coordinates of the surface presented in a fine resolution mesh, providing full-field information about:

- 3D coordinates of the component's surface
- Form change (major and minor strain)
- Thickness reduction
- Forming Limit Diagram (FLD)
- Formability
- Sheet metal hardening

The forming results are subsequently compared with the Forming Limit Curve (FLC), a material parameter dataset describing the maximum formability, by means of a Forming Limit Diagram (FLD) that is created in GOM Correlate Pro. This diagram clearly indicates whether the areas are over-deformed or still within a certain safety margin, providing decisive information for optimizing forming processes and validating simulations.



Before optimization



After optimization

Applications

Detection of critical deformation areas

Solving complex forming problems

Validation and optimization of numerical simulations

Tool try-out

Series production ramp-up

Material acceptance test (material batches)

Research and Development

Technology

Photogrammetry Principle

The certified handheld ARGUS camera is used to record deformed sheet metal parts from different viewing angles. In all acquired high-resolution images, 2D coordinates of all dots are mathematically derived and recalculated to 3D coordinates using photogrammetry principles, taking into account ray intersections, camera positions and lens distortion. The main result is a fine 3D point cloud, consisting of thousands of points, which represent the 3D surface of the sheet metal part.

By evaluating the relative distance between the points and with a local plane strain tensor computation, the principle strains (major strain and minor strain) and their corresponding directions are determined. The strain results are representing a full-field measurement result, as the measurement is carried out with thousands of measuring points.

In the software, the Forming Limit Curve (FLC) is automatically included together with the strain results in the Forming Limit Diagram (FLD), which supports an easy understanding of the forming analysis. With this measurement method, parts with sizes of several centimeters and complete side walls of cars are analyzed successfully nowadays.

Technical Data

System configurations	21 M
Sensor Dimensions	90 × 70 × 120 mm³
Weight	0,7 kg
Transport Case	465 × 195 × 400 mm³
Camera Resolution (21M)	5568 × 3712 pixels
Measuring Area	100 m² up to >> m² (freely adjustable)
Measuring Points	Typ. 10 000 to 300 000
Strain Range	0,5 % up to > 300 %
Strain Accuracy	Up to 0,2%
Cablibration	Self-calibration
Computer	64 Bit, 2.6 GHz Notebook or 64 Bit PC

Workflow

Easy and Fast Measurement

Measurement Planning
Before preparing the part, the measuring areas need to be defined depending on the evaluation purpose, which may be the complete part or specific critical areas known from the production process or numerical simulation.

Preparing
Before forming, raw sheet metal blanks are marked using electro-chemical etching or laser marking with a hexagonal dot pattern.

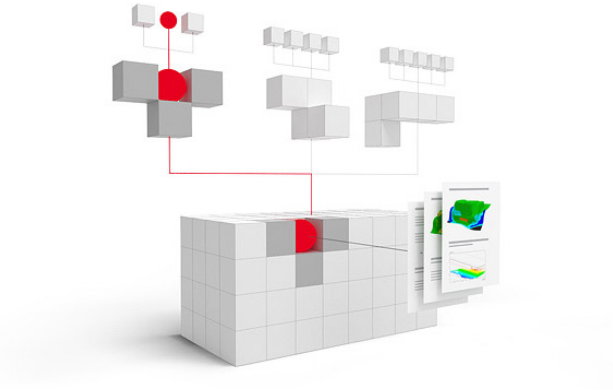
Measuring
After forming, the sheet metal part is recorded from different viewing angles by using the handheld ARGUS system. Small and large parts can be measured very fast with the same hardware.

Evaluation
Measuring results provide full-field information of the forming distributions on the parts, like major and minor strain, thickness reduction, forming limits, formability etc.

Measuring and Evaluating

GOM Correlate Pro

Based on the measuring data acquired by the ARGUS photogrammetry camera, the software provides a fast and efficient evaluation workflow for forming analysis.

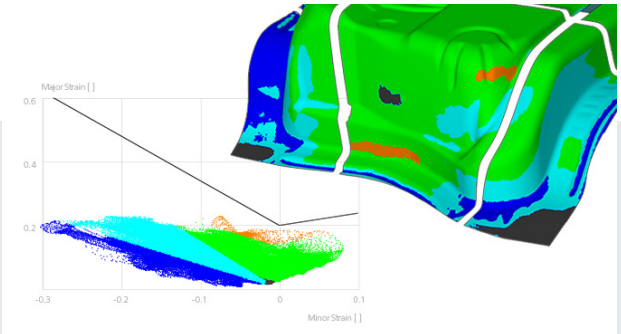


Parametric project templates

The software is based on a parametric concept. This approach ensures that all process steps are traceable, thus guaranteeing process reliability for measuring results and reports. In the evaluation process, all steps, including the creation of alignments (for example by CAD), inspection elements and the complete user-defined reports are documented and can be saved as project templates. Further projects of the same type can be easily repeated by simply changing the measuring data and recalculating the project. This project template can be stored and exchanged between colleagues, departments or even plants worldwide, which guarantees uniform evaluation standards for your projects.

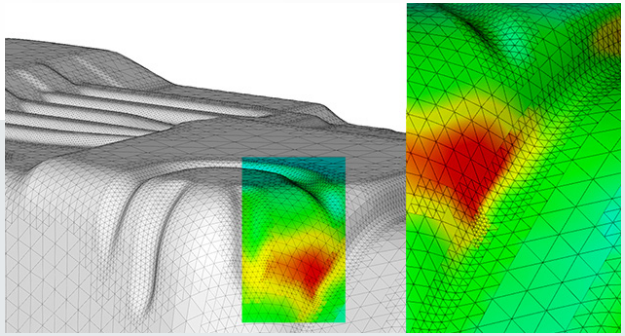
Guided data acquisition

A successful evaluation requires high-quality measuring data. The active guidance in GOM Correlate Pro provides a direct feedback on the image quality during the image capturing process. Images are automatically considered usable or unusable and displayed clearly in the software. Users can react to the messages shown by those unusable images to adjust the position, change the luminous intensity, for example, or just give a second try. With the new image mapping functionality, the measuring positions are displayed around the object, which makes the missing measuring positions directly visible.



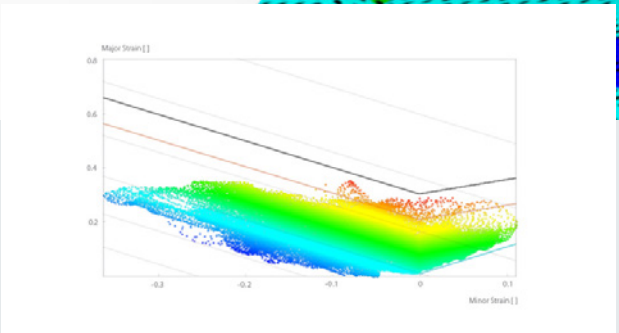
Formability

Formability analysis takes one step further. Like in many simulation programs, such as AutoForm, this formability diagram can also be created by one click in GOM Correlate Pro. The user can define different classification areas and visualize them directly in the Formability Diagram and on the specimen for further inspections.



Simulation

Scalar values and geometries from simulation programs such as ABAQUS, LS-DYNA or ANSYS, for example, can be imported into the software for a direct comparison to the 3D measuring data. The 3D measuring data can be transformed into the coordinate system of the simulation model by various alignment functions. Thus, the geometry of the simulation model can be compared with the measured 3D surface in a first step. Further analyses, such as the direct comparison of displace-ments, deformations and strain, can be carried out for each stage.



FLD/ FLC

The Forming Limit Diagram (FLD) is a proven tool to evaluate the forming process and determine the trend towards cracking. In GOM Correlate Pro, the FLD can be easily created with one click in I-Inspect. Besides the Forming Limit Curve, additional curves such as the Security Curve, Thickness Reduction Curve, Isotropic Tension Curve, can all be visualized in the software. Furthermore, multiple Forming Limit Curves (FLC) can be created by simply importing the ARAMIS material file or calculated directly in GOM Correlate Pro by Keeler for further analysis.

Automated mesh generation

Fewer user interactions are now needed to obtain results. The automated starting point allows automatic identification and computation of 3D meshes of single or multiple measuring areas. These meshes can be created independently of the user, which increases the repeatability of the measuring results.

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