Chair of Metal Forming and Casting
TUM School of Engineering and Design
Technical University of Munich

utg Newsletter Issue 13 12/2025

Chair of Metal Forming and Casting

"That which our calculations fail to predict, we call coincidence"

Albert Einstein
*1879 †1955 German Physicist and Nobel Prize winner

editorial

Dear readers,

Just in time for Christmas, our latest *utg* newsletter is ready. It's a little Christmas present from our entire team. As always, there is also a short video review of the year, which summarizes our team's many activities throughout the year in pictures.

In addition to general information, we take a closer look at three very different research projects (pp. 6-8).

We would also like to congratulate our former *utg* doctoral student, Dr. Milan Nedeljković, on his planned appointment as CEO of the BMW Group. This shows that in-depth knowledge of forming and casting technology can be very helpful in your career.

The entire chair wishes you all a relaxing and enjoyable Christmas season and all the best for the new year 2026.

Enjoy reading!

Yours

Wolfram Volk

Prof. Dr.-Ing. Wolfram Volk *Photo: A.Heddergott/TUM*

Cover:
Staff photo, October 2025 - Photo: *utg*

news

Kick-off for DFG Priority Program 2476

In spring 2025, the German Research Foundation (DFG) approved funding for twelve projects in the new SPP2476 on *cross-process modeling in production engineering*. In short, the core idea of the priority program is to reformulate process chain design as an inverse problem, taking stochastic uncertainties into account. Each of the 12 projects is carried out by two or three research centers in production engineering or materials science. In total, 28 subprojects from 22 research institutions across 14 universities are involved. The *utg* is involved with two scientific projects and the coordination of the SPP.

First meeting in September

For the official launch, nearly 55 people gathered for a two-day kick-off meeting at the AI production network's premises at the University of Augsburg.

photo: AI production network, Augsburg

In addition to getting to know each other personally, the focus was on professional exchange.

Work assignment explained

In his welcome address, coordinator Wolfram Volk outlined the goals for the next three years:
external visibility, high-level publications and conference contributions, and cross-project working focusing on four aspects of modeling.
On the second day, the newly formed working groups immediately set to work on their tasks. Overall, the presentation of the individual projects impressively demonstrated the diversity of the process chains that are being brought together in the SPP.
Further information on the content and progress of the projects and working groups can be found at the following link:
utg/dfg-schwerpunktprogramm-2476/

New location for the free-form bending machine

A significant step for our testing infrastructure: the 6-axis free-form bending machine has found its new home in the *utg* test hall. With the closure of the Hochbrück off-site location, it was absolutely necessary to create sufficient space in our test facility for the machine and its accessories. Thus, we took the opportunity to make more efficient use of the existing space and, through a joint effort, completely rearranged and tidied up the hall.
The new location also has the advantage of making our free-form bending research more visible to students and visitors. Thanks to the increased visibility of this exciting forming technology, we also expect to see a noticeable increase in interest from our industrial partners.

There is still work to be done to further optimize the infrastructure and improve workflows in the long term.
If you would like to gain a little insight into bending technology, scan the QR code or follow the link.

Video free form bending process

news

NUMISHEET 2025 Munich – a great success

We were delighted to have the honor of welcoming the global community for numerical simulation in sheet metal forming to Munich in July. **As conference chairs, Wolfram Volk and Christoph Hartmann welcomed over 255 participants from 23 countries, including 100 colleagues from Asia alone.**

The NUMISHEET conference thus underscored its international relevance and interdisciplinary reach in science and industry.

Keynotes and symposia

Eight internationally renowned **keynote speakers** kicked off the morning and afternoon sessions. They reported on the latest developments in their fields and provided exclusive insights into their research on simulation in sheet metal forming.

In an **honorary symposium** entitled “Mechanics of Sheet Forming,” **Farhang Pourboghrat** was recognised for his outstanding contributions in this field. The session brought together leading researchers to reflect on his influence and discuss future perspectives inspired by his work.

Across **eleven additional mini-symposiums**, more than 140 presentations were delivered, and participants engaged in intensive discussions on modeling, material characterization, measurement technology, and much more.

The contributions to NUMISHEET 2025 were published as open access:

IOP Journal of Physics: Conference series, volume 3104

Benchmark Challenge

Benchmark studies are a regular feature of all NUMISHEET conferences. A year in advance, we defined two challenging forming problems and asked the community to make predictions.

The best results submitted were honored at the conference:

- **Industrial Benchmark**: Designing the forming-cutting process chain for the Mercedes-Benz T-Node
  Top finishers: 1. **Alper Güner** (AutoForm Engineering GmbH); 2. **Gabriel Marín**, (IUL, TU Dortmund); 3. **Nikolay Biba** (Micas Simulations Ltd., QForm Group FZ LLC)
- **Scientific Benchmark**: Material Under Control MUC – calibration of a material model
- **Top finishers**: 1. **Alper Güner** (AutoForm Engineering GmbH); 2. **Subir Roy** (eta Engineering Technology Associates, Inc.); 3. **Monica Trask** (IUL, TU Dortmund)

The data and results of both studies have already been published:
https://doi.org/10.5281/zenodo.17662411

Beyond the technical program, NUMISHEET 2025 stood out for its excellent organization and relaxed atmosphere, which participants are sure to remember for years to come.

A very special thank you goes to our sponsors:

AUTOFORM Forming Reality

Zwick / Roell

Ansys eta Innovation Starts Here

MatchID Metrology beyond colors

news

Research meets industry – *utg* at trade fairs

As a chair with application-oriented research, we place great importance on close collaboration with industry. Trade fairs are a great platform for us to present ourselves and our research, gather ideas from practical applications, and strengthen our partnerships. Through our presence at events such as Blechexpo and Formnext, we build bridges between science and industry, which help us to develop innovative technologies together.

Blechexpo 2025

This year, we were once again present at the EFB joint stand. Here we met many visitors from the sheet metal processing industry who were interested in our work. As a highlight, we presented the MUC test we developed as a validation experiment for precise material models in forming technology. The trade fair provided an excellent opportunity to establish new contacts with European industrial companies in the stamping and forming technology sector.

Michael Ott, Phillip Stöcks-Morgan and Marios Demetriades represented the utg on the first day of Blechexpo, Photo: utg

Formnext 2025

As a member of TUM.additive, we presented our innovative molten metal jetting process at Formnext in Frankfurt. The aim was to promote this technology among a wider specialist audience and highlight its potential for additive manufacturing of metals. The response was overwhelmingly positive. The trade fair provided us with an ideal platform to showcase our approach and establish valuable contacts with industry and research partners.

Benedikt Kirchebner, Max Plötz and Christoph Weidner informed themselves at the formnext in Frankfurt, photo: utg

Looking ahead

The contacts and inspiration gained from both trade fairs are important driving forces that help steer our research in the right direction.

To make it easy for industrial partners to contact us outside of trade fairs, we have added a new page to our website: https://www.mec.ed.tum.de/en/utg/industry/.
Here you will find all the information you need about the opportunities for collaboration between the chair and industry. You will also find an overview of the research areas we are currently focusing on.

Write to us at our new email address:
partner.utg@ed.tum.de.
We look forward to actively shaping the future of manufacturing together with our partners.

current research at *utg*

casting

Warm crack detection using fiber Bragg gratings

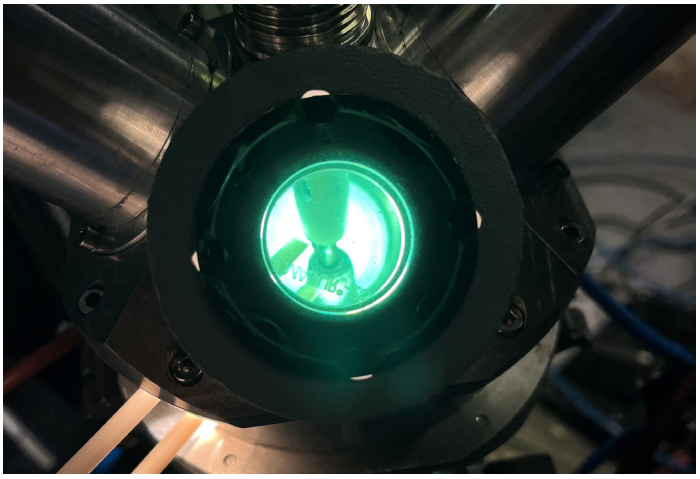
Motivation

Fiber optic measurements using fiber Bragg gratings (FBG) have been used in the past to determine internal stresses occurring during the solidification of cast components. This gave rise to the motivation to also detect the formation of casting defects, such as hot cracks, in the future.

The use of **FBGs** is an attractive measurement application, especially for cast components, as the glass fibers are temperature-stable up to approximately 1000°C and, with a diameter of only 125 µm, have hardly any structural influence on the cast component.
One disadvantage of FBGs is their cross-sensitivity to temperature and strain. This problem is usually addressed using various strategies, the most common of which is temperature compensation using a secondary temperature measurement profile.

Procedure

In addition, the fibers must be precisely calibrated to the measured variables. Therefore, in a first step, temperature measurements were carried out in liquid aluminum drops under weightlessness. Under these conditions, the aluminum alloy can solidify into spherical samples within a homogeneous temperature field and without external influences.
These boundary conditions reduce internal stresses to a minimum, and the FBG measurements are influenced only by temperature.
In a second step, tensile bars with integrated FBGs were manufactured from the same aluminum alloys. These samples were used to investigate the behavior of the fibers at room temperature up to the solidus temperature in order to determine a precise calibration of the FBG signal for strain measurements at high temperatures. In the final step, hot cracks were induced in the tensile specimens so that they could be recorded in situ. The data obtained can be used to determine material-specific thresholds at which the aluminum alloys begin to form hot cracks.



High-temperature tensile test during the heating cycle in the mirror furnace, Photo: utg

Results and outlook

The data obtained and the understanding of the occurrence of warm cracks can be used to reliably predict warm cracks with the aid of simulations.
The project was funded by the German Research Foundation (DFG) under project number 456662088.
Publications on the topic are available in open access and linked on the chair‘s website.

Contact: Constantin Bauer, M.Sc.

Principal Inspector Constantin Bauer, TUM (left), and Marcelino Dias, UAlberta (right), before departure of the Zero-G, Photo: utg

current research at *utg*

cutting and blanking technology

Shear Cutting Strategy on Hydrogen-Induced Crack Tendency

Motivation

The use of high-strength steels in industrial sheet metal forming is complicated by their susceptibility to hydrogen-induced cracking. Hydrogen atoms diffuse into the material during its manufacture or processing, causing it to become brittle. Cracking often occurs unexpectedly and with a time delay below the tensile strength of the material. The material properties, the hydrogen content in the material, and the mechanical stress are particularly important factors here.

Approach

The research project investigated how various cutting parameters and shear-affected zone properties affect the hydrogen embrittlement susceptibility of three dual-phase high-strength steels. An experimental setup was used to replicate the introduction of hydrogen during industrial manufacturing processes. In order to evaluate the influence of shear cutting parameters on hydrogen-induced failure, the loaded samples were manufactured with different shear cutting parameters (see Figure 1) and then subjected to Slow Strain Rate Test (SSRT) and Constant Load Test (CLT). A two-dimensional FEM shear cutting simulation was used to investigate the distribution of the shear-affected zone induced by the different cutting parameters and it was validated by hardness measurements.

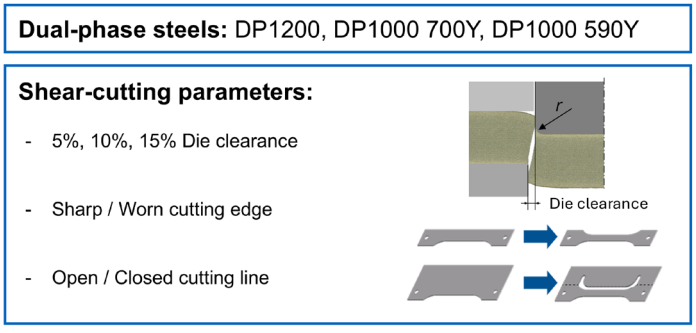


Figure: The dual-phase steels and shear-cutting parameters used for identifying the influence of different cutting strategies

The experimental and simulation results were used to create a metamodel that describes the relationships between the cutting parameters, the properties of the shear-affected zone, and the hydrogen embrittlement susceptibility of the selected materials, and thus contributes to the selection of the improved cutting strategy for hydrogen-loaded materials.

Results and Outlook

The findings of this project aimed to provide an in-depth understanding of the relationship between cutting parameters, shear-affected zone properties, and hydrogen embrittlement susceptibility. The most significant result was that samples cut with a 5% die clearance, sharp cutting edge, and open cutting line geometry showed the greatest fracture strains, likely due to the smallest hardening depth of the shear-affected zone predicted by the simulation for this configuration. These results suggest that optimizing cutting parameters, particularly minimizing die clearance and using sharp cutting edges, can significantly influence hydrogen embrittlement susceptibility, which is especially important under industrial conditions.

Acknowledgement and publication

The research project **"***Influence of the shear cutting strategy on the hydrogen-induced crack tendency***"** was funded by the Federal Ministry of Economic Affairs and Energy as part of the **"**Industrial Collective Research**"** programme on the basis of a resolution of the German Bundestag. This project FOSTA 22441N from the Research Association for steel Application (FOSTA), Düsseldorf, was carried out at utg.

The final project report contains comprehensive descriptions of the research approaches, work content and findings and will be available from the Research Association for Steel Application (FOSTA) shortly.

INDUSTRIELLE GEMEINSCHAFTSFORSCHUNG

Kontakt:
Lysimachi Iona, M.Sc.

current research at *utg*

forming technology

Optical Deformation Analysis and Virtual Lab Validation

This research project focuses on the precise optical measurement and analysis of deformation in sheet metal specimens under mechanical loading. Its core objective is to advance and validate modern Digital Image Correlation (DIC) and optical flow estimation methods.

Motivation

Optical measurement methods offer a flexible and cost-effective way to detect deformations, but reach their limits with complex 3D surfaces, strain calculations, crack detection, and poorly defined environmental conditions. Furthermore, robust validation frameworks for algorithmic accuracy are currently lacking.

Project Approach

Within the framework of a DFG-funded project, the utg research group is developing a comprehensive virtual laboratory based on computer simulations of the Nakajima experiment. This laboratory generates realistic, artificially generated images and simultaneously provides a complete baseline for the deformation. This allows for the systematic investigation of the influence of illumination, noise, camera geometry, and sample configuration on the accuracy of the deformation analysis.

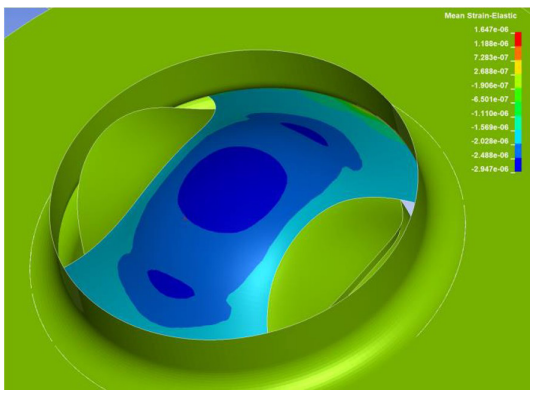


Fig. 1: Simulation of the Nakajima experiment with the simulation software LSDyna

Extension to the MUC-Test

The project transfers this approach to the MUC test, a novel method for validating material models. The Virtual Lab enables realistic image acquisition from different perspectives, optical flow calculation, 3D reconstruction, and strain determination for both experiments.

In the experiment, two cameras capture image sequences from different perspectives over time. This results in two different images per time step, from which the object's three-dimensional surface can be reconstructed. Simultaneously, the deformation can be calculated by comparing images from different time points. From these two pieces of information, the three-dimensional deformation can be reconstructed. This can be compared to the fundamental data, for which the deformations are directly extracted from the physical simulation. The results show high qualitative agreement and identify optimal parameter ranges as well as sources of error.

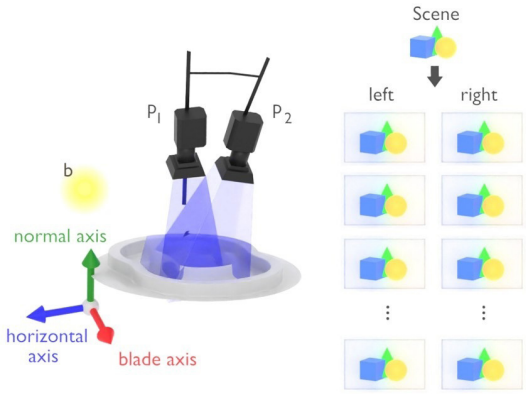


Fig. 2: Schema zur synthetischen Bilddatenerzeugung im Virtuellen Labor des MUC-Tests.

Scientific Contribution

This project provides, for the first time, a complete validation framework for 3D OME and DIC methods. It allows for objective error quantification, reproducible scenarios, and recommendations for experimental optimization. It thus forms an essential basis for more precise and efficient material characterization in future experimental series.

Contact: Paul Richter, M.Sc.

events at *utg*

Stamping Technology in Dortmund

Under the motto "**Quo Vadis Stamping Technology?**", the 16th edition of the Stamping Technology Congress will focus on three key topics for the future of the industry.

Chat GPT as a booster:
Language models for stamping technology
The interdisciplinary program section will focus on the application of AI language models in production technology. There will be keynote speeches and a panel discussion on the morning of the second day of the congress. Concrete applications of "large language models" for medium-sized industry will be presented and discussed.

Smart production and materials in transition
The second focus, under the motto "**Smart Production Lines**," is on intelligent automation solutions. The third topic, "**Materials in transition: powerful – durable – sustainable**," focuses on new and robust materials and standard parts.

Further information on the agenda, participation fees, and registration can be found on the website
www.kongress-stanztechnik.de

The conference language is german.

The renowned Stanzkongress is once again being organized by the Dortmund-based event agency STRATEGIEX.

personnel at *utg*

We extend a warm welcome to:

Laura Thackray, M.Sc. joined the forming group on October 6, 2025.

Vivian Wagner, M.Sc.
joins the casting group on January 1, 2026

We wish all the best for the future:

Katja Martinitz, née Holzer, M.Sc. is leaving the *utg* on Dezember 31, 2025.

Lucas Böhm, M.Sc. is leaving the *utg* on Dezember 31, 2025.

new dissertations at *utg*

57 **Kirchebner, Benedikt**: Hybrid Material Jetting - Expanding Molten Metal Jetting with Molten Salt Jetting for Realizing Water-Soluble Support Structures, Juli 2025

All publications and dissertations of the chair are listed on the website www.mec.ed.tum.de/en/utg/home/
The dissertations appear printed in the ***series Metal Forming and Casting***, ed. Prof. Dr.-Ing. Wolfram Volk, pub. Kollemosch Verlag & Kommunikation,
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