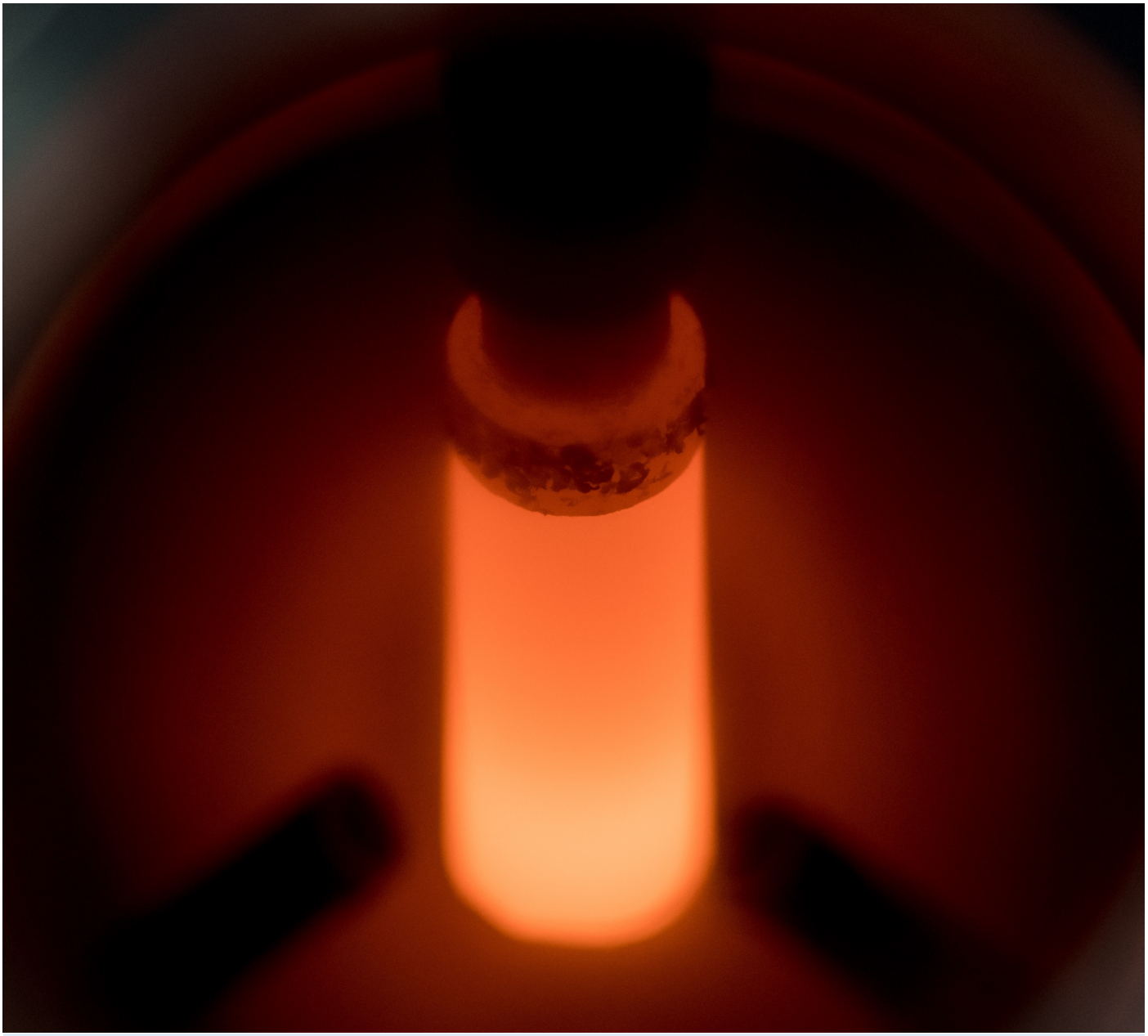
Chair of Metal Forming and Casting
TUM School of Engineering and Design
Technical University of Munich

utg Newsletter Issue 7 12/2022

Chair of Metal Forming and Casting



„Science is made by people“

Werner Heisenberg, 1901 - 1976, German physicist and Nobel Prize winner

Editorial

Dear readers

Incredible but true, the year 2022 is drawing to a close with seven-league boots on. I am sure that it will remain a lasting memory for all of us.

As I'm sure you can imagine, the global and national uncertainties pose great challenges, even for a university chair. It is practically impossible to make a forecast for the future now. The extent to which existing funding opportunities will be available in a comparable form in the near future is currently completely unclear. We are therefore, of course, carrying out scenario management and thus preparing ourselves for the near future.

However, I am firmly convinced that we should continue to work with a healthy optimism despite all the boundary conditions that are difficult to predict. For our chair, this means that we will continue to look after third-party funding, young scientists, and industrial projects in the customary manner.

We hope to be able to give you an interesting insight into current activities and research projects in the current newsletter as is usual.

With this, I wish you a not too stressful pre-Christmas period and, of course, lovely holidays and some rest over the turn of the year.

Yours

Wolfram Volk

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

Frontpage Image:
Composite Casting on a Laboratory Scale - Graphite Crucible in the Analysis Furnace
Image: Tobias Hase, utg

utg News

All the Best for the Future

Photo: Heddergott/TUM

After more than 30 years of dedicated work for the utg, we had the pleasure of bidding farewell to our chief engineer Dr.-Ing. Roland Golle at the end of September. This marks the end of an era at the utg, but he will certainly have more time for extended bicycle tours and travel.

We wish Roland Golle all the best for the future and will greatly miss his profound expertise, his scientific competence, and his many years of experience.

Of course, this vacancy cannot be easily filled, so we at the utg have decided to take a new path and hire three young scientists to head the department to make the transition as smooth as possible.

With Christoph Hartmann, Philipp Lechner and Florian Steinlehner, we have three utg homegrowns who will represent the new management of the utg with their professional and personal expertise.

We look forward to exciting challenges in the future.

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Partnership with Aalto University

Back in March 2019, the President of Finland's Aalto University, Ilkka Niemelä, and the then TUM President Wolfgang A. Herrmann initiated a partnership between the two universities.

At the beginning of December, the scientists met in Helsinki, Photo: utg

As part of this cooperation, the utg has now laid the foundation for a longer-term bilateral collaboration with Prof. Junhe Lian's Advanced Materials and Manufacturing group (AM2). The first step was taken in September at a one-week workshop in Garching. The diverse visitors' program included, among other things, a visit to the FRMII research reactor, several institute and chair tours, discussion rounds on future collaboration, and scientific work sessions on selected interdisciplinary topics.

The colleagues from Helsinki specialize in state-of-the-art multiscale characterization and modeling of materials during manufacturing. For this purpose, Prof. Lian's group has excellently equipped laboratories for non-destructive testing, advanced manufacturing, microstructural characterization, and mechanical testing with digital image correlation. The utg brings an excellent infrastructure and a lot of experience in materials testing, characterization, and manufacturing to the partnership.

The expertise of the AM2 group at AALTO on the micro scale (testing, material modeling and simulation) therefore ideally complements the utg's research strengths on the macro scale (processes, testing, material model-

ing, simulation) and enables cross-scale problem solutions.

In the short term, joint publications, and conference contributions as well as the mutual exchange of researchers are on the agenda. At the beginning of December, Christoph Hartmann returned from a four-week research stay in Helsinki, and in October Rongfei Juan spent three weeks at the utg.

Long term, joint research projects are to be submitted on an EU level and an expansion of the cooperation on a departmental and school level is certainly also interesting.

Tradition at the "Sommertreff 2022"

Every year, representatives from academia, research and industry, all current employees as well as alumnae and alumni meet for a relaxed get-together in Garching.

A Serenade to the utg “Hausmesse” from the AGV, Photo: utg

The popular, traditional event finally took place again on the 21.7.2022 in the courtyard and experimental hall of the utg after a long forced break.

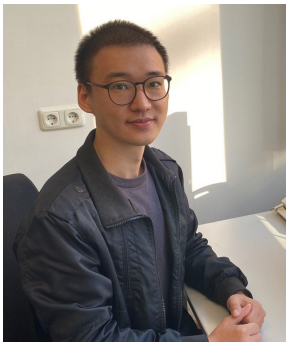
Over a delicious buffet and hearty Bavarian music, it once again became clear how important personal discussions are in a relaxed, stress-free, almost private setting. In addition to networking, the focus was on development opportunities and cooperations of various kinds. Around 250 guests took part in the event, which is also known as the "Hausmesse". The unanimous verdict: a thoroughly successful evening.

Tribute to the 80th Birthday of Prof. Hoffmann
During the "Sommertreff 2022", Prof. Hoffmann was honored on his having reached the age of 80. Highly esteemed and unique", "best gentleman in the world", "stroke of luck for the chair", "as a person committed, helpful, yet calm and reserved", "we are happy to have

Celebrant Prof. Hartmut Hoffmann, Photo: utg

him with us", these are the words of the laudation, which Professor Breun held in place of the ill chair head Professor Volk.

We Welcome Dr. Qi Hu at the *utg*



Dr. Hu works at the utg together with his colleagues in the forming department. He deals with the theory of plasticity and the simulation of sheet metal forming.

utg News

Profile Qi Hu

Nationality: China

Home Institution: Korea Advanced Institute of Science and Technology

Education: Doctor of Materials Science and Engineering in Shanghai Jiao Tong University, June 2019, China

Age: 32 years

Research focus: The theory of plasticity for sheet metal forming

Research Project at TUM: Springback Prediction for Sheet Metal Forming

Favorite Place in Munich: English Garden

15. Bavarian Barbara Conference

Mastering the present - setting impulses for the future

On the 1. December, after a break of several years, we could finally hold the Barbara celebration in Garching. The occasion for the traditional event is regularly the name day of St. Barbara, patron saint of miners and foundrymen.
In addition to Gießereitechnik München with utg and Fraunhofer IGCV, the VDG Bavarian Association also participated in the organisation this year.

The **first technical lecture** was given by **Maximilian Engels**, Managing Director of Technical and Regional Associations of the "Bundesverbandes der Gießereiindustrie" BDG. With his industry political topic "**Exciting times for the German foundry industry**", Mr. Engels shed light on the current difficulties of the industry, in particular due to the high energy costs and the shortage of raw materials. His presentation, illustrated with many charts, ended with the challenge of the shortage of skilled workers. The solution to this problem certainly has a socio-political dimension, which we should address in the combination of academia and industry with creative proposals for solutions.

Maximilian Engels from the "Bundesverband der Gießereiindustrie", Photo: utg

The **next talk** focused on the application-oriented topic of "**Innovative foundry solutions for the Automotive Body Production of the Future**". **Dr. Thomas Kopp** and **Dr. Bernhard Frodl** from the **BMW Group** offered an exciting insight into the topics of cast components and lightweight construction in the age of e-mobility. The speakers vividly demonstrated that there are very different approaches to solving problems, which are currently being worked on extensively. For large cast parts, the speakers were convinced that, in addition to sufficient dimensional accuracy and mechanical characteristics, a customer-friendly repair concept must also be available.

Wolfram Volk Welcomes Thomas Kopp and Bernhard Frodl from BMW AG, Photo: utg

utg News

With the following **research marketplace**, the foundry technology in Munich broke new ground. Instead of another program of lectures, the research institutes Fraunhofer IGCV, TUM Chair of Metal Forming Casting (utg) and the two universities of applied sciences Kempten and Aalen presented their current research and topics at a total of nine booths. This gave visitors the opportunity to engage in direct discussions with young scientists on

Steffen Klan (IGCV) does the Tapping Himself, Photo: utg

exciting projects. As always, there was plenty of time for **discussions and networking**. The evening ended in the old tradition with a hearty meal.

Status Meeting on SPP2013

In big strides, the DFG priority program 2013 is entering its final round.

Before the projects come to a close next year, they were presented once again with information on the current state of research. The last consortium meeting for the SPP took place at the TU Darmstadt on 12. /13. October 2022. It was headed by Prof. Wolfram Volk. He was responsible for the project coordination of the SPP2013 from the beginning.

The scientists involved were extremely satisfied with the results achieved so far with regard to the objectives:

- Predictability of the property improvements of the components in operation with the aid of suitable prognosis models
- Design, layout, and optimization of the processes (with regard to the specific application)
- Proof of residual stress stability under given application boundary conditions

Using findings in research and industry

After six years of research, one would naturally wish to use the results in a variety of ways and thus also pass them on for teaching purposes. In the four professional circles relevant topics were determined, which are to be illustrated on teaching slides. The target group for this are students in the 5th semester of their bachelor course. "It would be desirable to transfer knowledge in 2023/2024 after the end of the project, with the aim of transferring the project results to industrial processes and components." This was already expressed by Prof. Dr. Ing. Volk a few weeks ago at the SPP2013 industry colloquium in Garching.

In the meantime, a wide variety of talks are underway with relevant industry partners. People are in a positive mood and highly motivated to apply the research in practice.

This was the Sixth Time that the Project Teams have Met Since the Start in 2017, Photo: TU Darmstadt

Current Research at *utg*

Outlook - final report in 2023

In the fall of 2023, at the end of project phase 3, the results of the overall project will be published in a detailed final report.

See here the projects on video:
https://www.youtube.com/@spp2013

Successful Trade Show

"Innovations as the key to tomorrow's sheet metal processing" was the motto of the EFB's joint booth at this year's EuroBlech in Hannover.

In addition to the results of residual stress research from SPP2013, the utg presented the in-house development of the so-called MUC test.

MUC test - acronym for Material Under Control
The test offers the possibility to examine material models in detail with low material input and to make statements about their quality. (See the *utg* Newsletter Issue 5, S.11)
For us, the trade fair appearance in Hanover was a premiere and we were able to benefit greatly from the professional preparation and marketing of the EFB.

Successful completion of bending assistance system project

The end of the year could not have been better, as we were able to complete our **first cooperation project** with the company **HÖRMANN Automotive GmbH** in the field of **free-form bending**.
We were pleased to work together with Dr. Daniel Holstein (Managing Director), Dr. Wolfram Schmitt (Head of R&D) and Andreas Wagner (Project Manager R&D) from HÖRMANN Automotive GmbH at the **Bending Centre Bavaria South (BiZeBS)** to conclude the joint cooperation project and at the same time to plan further joint steps for the further development of free-form bending.
Within the framework of the 3-year project, **Lorenzo Scandola** developed a **bending assistance system bendex (BENding EXpert)** in cooperation with HÖRMANN Automotive GmbH, which enables a faster and more robust process design of free-form bending.
The aim was to identify and address problems that currently limit the further development and widespread use of free-form bending. In this way, the current time and cost expenditure could be reduced and the process steps from component design to production reduced. In order to bring free-form bending out of its niche and up to industrial use, it is important to have an assistance system.
The software takes care of the most important steps to make the **process design of free-form bending sequential**. This includes the extraction and conversion of the target geometry in the corresponding bending programme, as well as the calibration and recognition of the process limits, down to the kinematic design of the bending head and the evaluation of the results, with the possibility of **performing automated compensation**.

However, this great advancement is not our final goal, but only a **new starting point for joint activities**.
Let's go!

Final Event with A. Wagner, Dr. Holstein, L. Scandola, Prof. Volk, Dr. Schmitt at the BiZeBS, Photo: utg

Current Research at utg

Casting

ALL4ADI - Extension of the Use of ADI

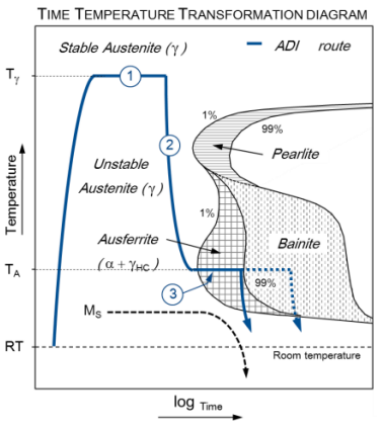
Initial Situation and Motivation

In the coming years, demand for cast iron will continue to rise in all areas of mechanical engineering as well as in energy technology and transportation due to its advantageous material properties. Austempered Ductile Iron (ADI) can be counted among the most promising casting materials of the future. The reason for this is the combination of excellent casting properties - typical of cast iron - with the mechanical properties of steels. This allows the production of components with highly complex geometries which are 10% lighter than those made of steel due to the lower material density.

Currently, however, both the manufacture of ADI components and their design are associated with many uncertainties. The project consortium aims to address this by taking a holistic view of the ADI manufacturing process.

Research Contribution of the utg

At the utg, the heat treatment process of spheroidal graphite iron (GJS) required for ADI production is to be investigated on a laboratory scale. For this purpose, a corresponding analysis furnace will be set up as a first step.



With this, the material is first heated to approx. 900°C and held (1). Subsequently, the sample must be cooled quickly to approx. 300°C (2). This temperature level is also held (3) before cooling to room temperature. (see fig.1)

In the analysis furnace (fig.2) , the temperatures, holding times and cooling rates of the heat treatment cycle can

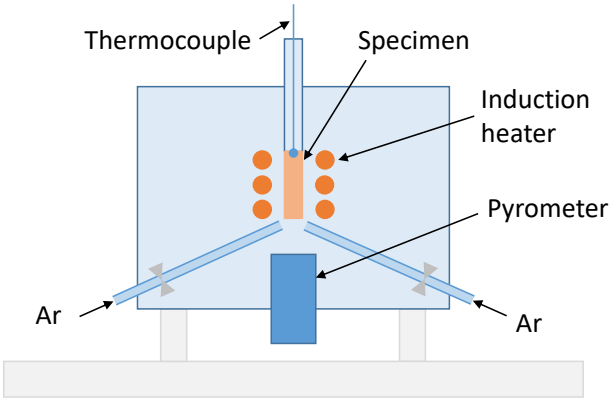


Fig. 2: Schematic picture of the analysis furnace

be varied for different alloy compositions. The resulting microstructures are then visualized by means of an appropriate etching treatment and then analyzed. For the evaluation, a machine learning algorithm is to be developed that can automatically recognize and name the individual phase components. Thus, the influence of the different heat treatment parameters on the final product can be determined. In addition, the heat-treated samples will also be subjected to a tensile test to determine the mechanical properties.

Results and Outlook

The results will provide engineers with a design concept for ADI components, enabling them to determine the correct heat treatment parameters, alloying elements and a suitable component geometry based on the product requirements.

The project started in 2022 and is funded by the Federal Ministry for Economic Affairs and Climate Action.

For more information visit our utg-website.

Further Project Partners

Institute of Metallurgy of TU Clausthal, Fraunhofer Institute LBF, ADI Treatments Ltd, ACTech GmbH, AEROVIDE GmbH, Buchholz & Cie. Giesserei GmbH, FONDIUM B.V. & Co. KG, Foseco Nederland B.V., MAN Truck & Bus, MATPLUS GmbH, TEUTOGUSS GmbH, RWP GmbH, Walzengießerei & Hartgusswerk Quedlinburg GmbH, Zanardi Fonderie S.p.a.

Contact: Christoph Weidner, M.Sc.

Current Research at utg

Cutting Technology

Reduction of Adhesive Wear

Motivation and Initial Situation

Adhesive wear and the associated swarf formation of particles are major challenges in the machining of aluminum and stainless-steel alloys. Damage to tools, presses, and peripherals as well as reduced component quality are the consequences of progressive adhesive wear during shear cutting.

Thermoelectricity and Adhesive Wear

Investigations at the utg showed that thermoelectric currents between the sheet and the cutting punch influence the adhesion initiation and quantity during the shear cutting process. The stronger the thermoelectric current flows, the higher the wear occurring on the tool active elements. Likewise, the flow direction of the current also influences the number of adhesions. The magnitude and direction of the current flowing between the two contact partners is directly dependent on the difference between the material specific Seebeck coefficients

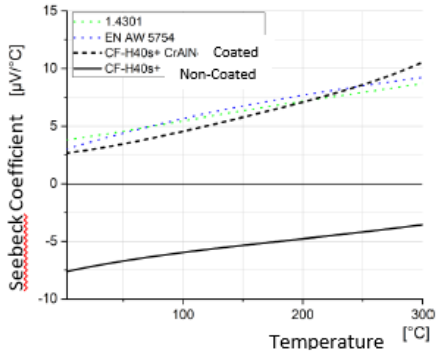


Figure 1: Seebeck Coefficients of Selected Materials

of the punch and the sheet.

Effect of Coatings

By means of an adapted coating of the active elements, it is possible to influence the Seebeck coefficient. The Fraunhofer Institute for Surface Engineering and Thin Films has developed a CrAlN coating that raises the combined Seebeck coefficient of the CF-H40s+ carbide and reduces the difference to aluminum and stainless-steel alloys. The developed layer is characterized, among other things, by very low electrical conductivity. Measurements of the flowing thermocurrents during shear cutting showed a reduction in these when using the CrAlN-coated active elements made of CF-H40s+

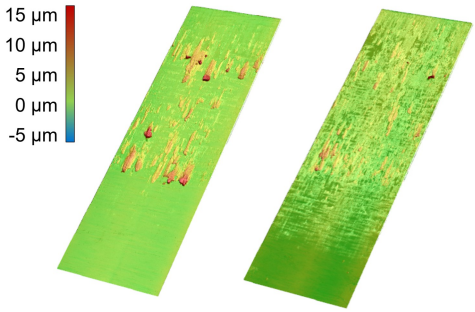


Figure 2: Stamp Lateral Surface of an Uncoated (left) and a CrAlN-Coated (right) Stamp made of CF-H40s+

compared with uncoated ones. An analysis of the amount of adhesion on the lateral surface of the cutting punches confirmed the hypothesis of reduced adhesions at lower thermocurrent.

Conclusion and Outlook

The investigations showed that it is possible to adapt the Seebeck coefficients of active element materials to those of sheet materials by means of special coatings. Consequently, the level of the thermocurrents flowing between the contact partners is reduced. It was also confirmed that a lower thermocurrent has a positive effect on the wear behavior of the active elements.

For use in an industrial environment, further development of the coating process is required, together with improved adhesion of the coating. Ultimately, a longer tool life and improved part quality will then be possible.

Contact: Agnes Schrepfer, M.Sc.

Current Research at utg

Forming

In-situ Investigation of Industrial Steels

Motivation

Increasing demands on formed components mean that sheet materials are constantly being further developed. For example, certain microstructural properties enable extremely good formability combined with high strength. However, this more complex microstructure leads to elastic-plastic properties that deviate considerably from classical theories. This in turn leads to challenges in numerical modeling, especially with regard to springback prediction.

Solution Approach

The project presented here is related to the overall goal of experimentally advancing the understanding of materials to improve springback prediction.

Figure 1 shows the elastic-plastic characteristics that are important for predicting springback with high accuracy and were investigated within this study. Here the plastic yield onset and elastic modulus at a steady elastic-plastic transition were determined, as well as the phenomena of elastic strain dependence, nonlinearity, and the Bauschinger effect.

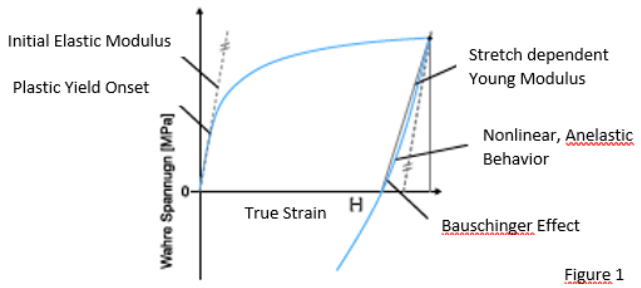


Figure 1

Results

The material behavior of a single-phase IF steel and a high-strength dual-phase steel was investigated in cyclic tensile tests and tensile-compression tests using in-situ synchrotron diffractometry at the German Electron Synchrotron (DESY, Hamburg).

The experimental setup developed for this purpose allowed the time-synchronous measurement of macroscopic strain, force and sample temperature and microstructural quantities such as lattice strains, dislocation densities and specific phase stresses (Figure 2).

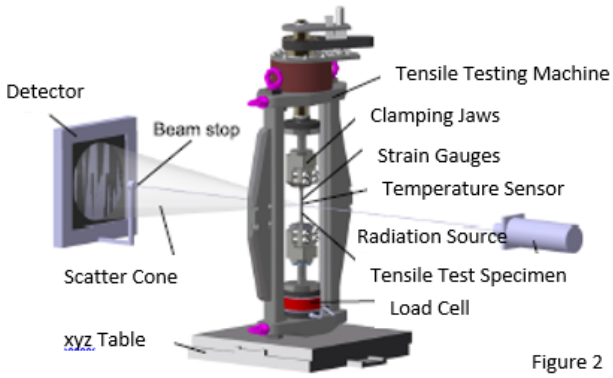


Figure 2

Thus, a correlation of the macroscopic material behavior with the microstructural behavior was possible. By investigating the onset of plastic flow due to lattice strain and displacement density, a temperature-based determination of the onset of flow could be qualified and validated.

Based on this, a temperature-based determination method of the elastic modulus was developed. In addition, the phenomena of strain-dependent Young's modulus and the Bauschinger effect, which are particularly pronounced in high-strength DP steel, could be better understood, and explained based on analyses of microstructural behavior.

By calibrating a widely used isotropic kinematic strain hardening model and performing a single-element numerical test, the great potential of the results of this study was demonstrated.

With the research results, the goal of the work, namely the further understanding of the material with regard to elastic-plastic material behavior, could be achieved. On this basis, it is now possible to extend existing modeling approaches so that a more precise prediction of springback can be expected.

Further Publications and Contact :
Simon Vitzthum, M.Sc.

Personnel at utg

We extend a warm welcome to:

Erwin Reberger, M.Sc. joined the Casting Group on 1 September 2022

Christoph Weidner, M.Sc. joined the Casting Group on 1 September 2022

Dr. Liudmyla Lisova joined the Casting Group on 1 November 2022

We wish all the best for the future:

Dr. Roland Golle started the retirement phase of his partial retirement on 1 October 2022

Events

4. Molding Forum

29 and 30 March 2023

For more information and the lecture program, please visit the vdg Academy website. vdg-Akademie.

Congress Punching Technology

17 and 18 April 2023

13. Kongress Stanztechnik
17. und 18. April 2023
Dortmund

On Monday, 17 April and Tuesday, 18 April 2023, the 13. Punching Technology Congress will traditionally be held at the Westfalenhalle in Dortmund. The main technical topics for the upcoming event are:

- New Work - New Working Worlds
- Electromobility - Manufacturing New Components for the Automotive Industry
- Smart Tooling - Tools of the Next Generation
- Networked Processes - Planning, Simulation, and Monitoring

Registration for the congress is possible via KIST e.V.

New Dissertations at *utg*

37 **Landesberger, Martin**: Characterization and Design of Enhanced Ductile Irons, June 2022

38 **Beulich, Nikolas**: Development of a Methodology for the Design and Validation of Freeform Bending with Moving Die for Three-Dimensional Bending Geometries, December 2022

All publications and dissertations of the chair are listed on the website www.mec.ed.tum.de/utg

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