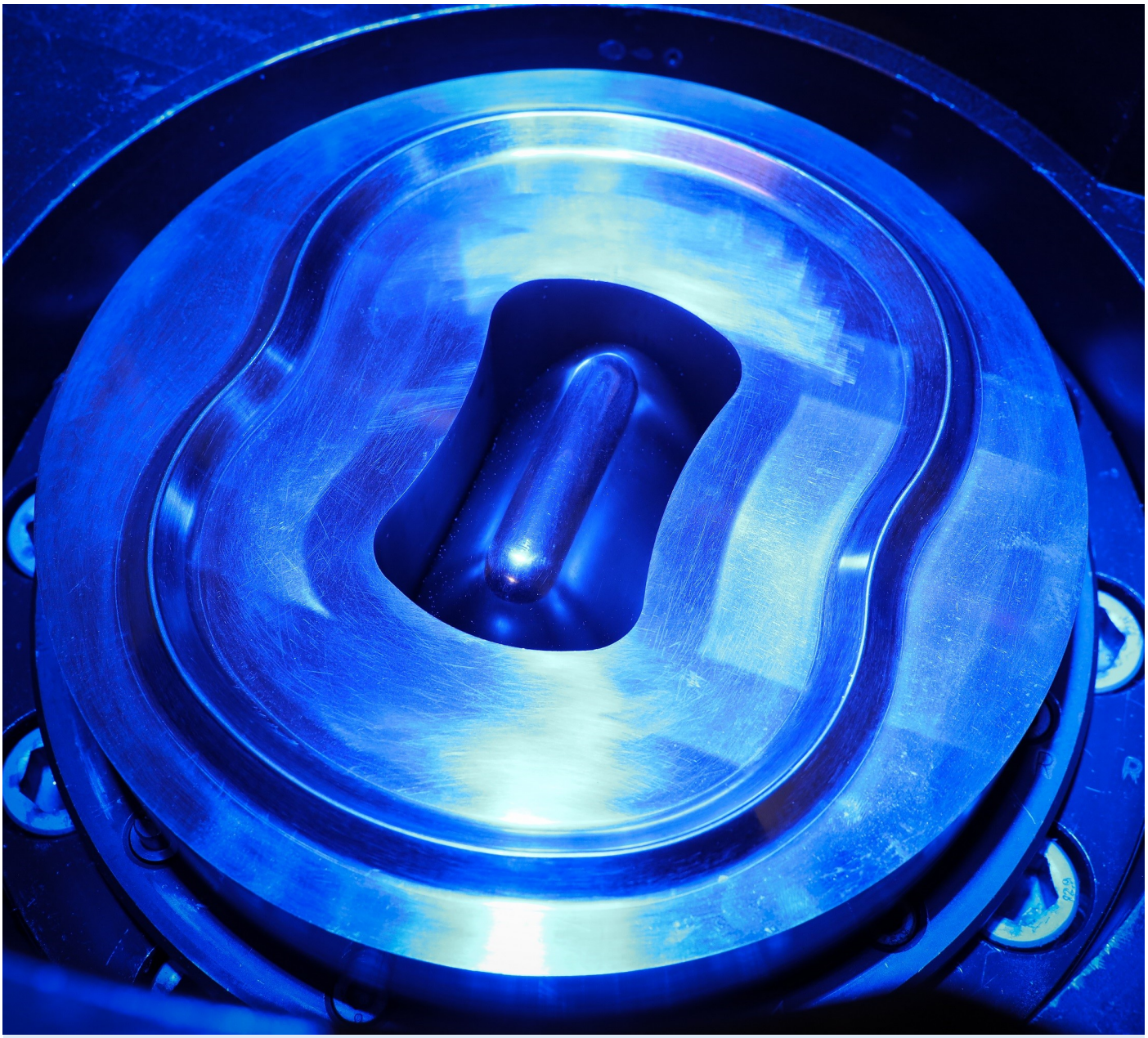
Chair of Metal Forming and Casting
TUM School of Engineering and Design
Technical University of Munich

utg Newsletter Issue 6 06/2022

Chair of Metal Forming and Casting



"It is not the world that makes these people, but these people that make the world."

Elfriede Hablé, 1934–2015, Swiss-Austrian aphorist and musician

Editorial

Dear friends of *utg*,

It is with immense pleasure that I announce the start of a return to normality in addition to the newsletter. After two cancellations due to Corona, it seems as of today that we will finally be able to hold our in-house exhibition as a summer meeting at the *utg* again. On 21 July, in keeping with our usual tradition, we will first begin with the alumni meeting and then meet in an informal atmosphere at the *utg* (experimental hall + forecourt). I also have two highlights to announce for this day: My esteemed predecessor and long-time professor at *utg* Prof. Hartmut Hoffmann celebrated his 80th birthday. We, the *utg* team, would like to honour this again together with you. For this purpose, there will be a presentation from around 7 pm. Furthermore, a main pillar of the *utg*, our chief engineer Dr Roland Golle, will enter the rest phase of semi-retirement in September. This will also be honoured at our event. We are confident that there are enough reasons to meet again in person at the *utg*. We look forward to seeing you.

But that is not all. As many of you may know, we the *utg* are coordinating the DFG's priority programme 2013 entitled "Targeted Use of Residual Stresses Induced by Forming Technology". The programme has now entered its third and final funding phase and overly exciting results have been achieved by all sub-projects. In this context, we are organising an industry colloquium on 22.6. in Garching with exhibition stands and interesting lectures on the topic of residual stresses. Participation is free (registration via the *utg* homepage). You are warmly invited.

With this, I would like to leave you with the best spring wishes and look forward to welcoming you in person either at the in-house exhibition and/or the industry colloquium.

Yours

Wolfram Volk

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

Frontpage Image:
Sheet metal holder and stamp of the MUC test tool. The MUC test (an acronym for Material Under Control) is used to check the quality of material cards for sheet materials.
Photo: Tassilo Letzel/TUM

utg News

EFB Award for Edge Crack Research

The **project prize** of the European Association for Sheet Metal Processing eV. (EFB) for outstanding scientific and technical research projects went to the *utg* this year: Dipl.-Ing. **Isabella Pätzold** was awarded for her research on **"Reduction of Edge Crack Sensitivity by two-stage Shear-Cutting".** Within the framework of the project, practice-oriented regression models were developed for dual-phase steel DP800 as well as for stainless steel 1.4301 based on experimental data.

Isabella Pätzold installing Tools on the Bruderer Press, Image: Hase/utg

These enable the selection of a process window that **allows components to be manufactured reliably even when taking wear into account.** Furthermore, they offer the possibility to estimate the residual deformation capacity already in the simulative design process and to determine adapted **re-cutting parameters** for critical areas. Components can thus be safeguarded at an early stage regarding the formation of edge cracks.

In the project, a **simulation model** was also set up that enables precise mapping of the two-stage shearing process. By comparing the experimentally and simulatively determined results, correlations could be formed that make it possible to determine **adapted re-cutting parameters** with the help of finite element simulation **without a high experimental test effort.**

The prize was awarded on 29 March 2022 at the EFB WebColloquium. The results were published in EFB Research Report No.562.

Efficient Production of Flat Tensile Specimens

The **tensile test** is one of the most important tests in materials testing. If the **flat tensile test specimen** has the wrong dimensions or is not of the required quality due to **incorrect processing**, such as surface roughness or geometric dimensions, this will result in **incorrect results** and measured values when the test is conducted. As a result, constructions, e.g., in mechanical engineering, vehicle construction, load-bearing structures, etc., can be incorrectly dimensioned and designed. Therefore, it is of crucial importance that the correct tolerances are maintained during specimen production and that no damage to the material and the microstructure is caused by the processing.

The following disadvantages result from the **production of the test specimens** with the existing methods:

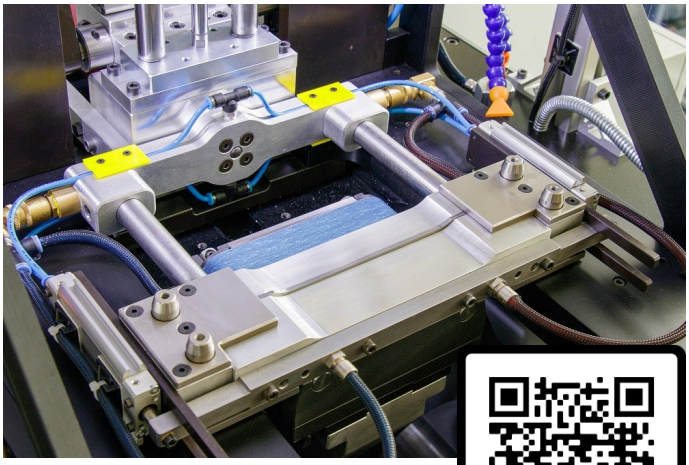
- The production by **punching** does not provide sufficient quality of the flat tensile test specimens due to the resulting work hardening and the burr.
- Skilled personnel are required for **milling,** and production is comparatively expensive and time-consuming. High-strength steels can only be produced with enormous tool wear.
- With **conventional grinding**, no automatic specimen production is possible and due to the increased heat input during machining, the specimens can only be produced with a high expenditure of time and potential microstructure change.

To ensure a **fast and cost-effective production** of flat tensile test specimens with a **high level of dimensional accuracy and quality,** a solution for the automated production of flat tensile test specimens is urgently needed.

The following requirements arise:

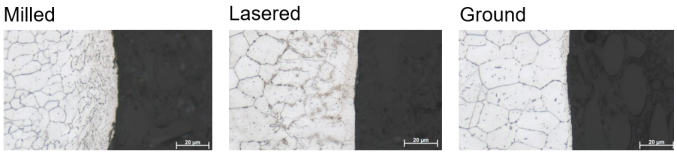
- User-independent, automated system
- Suppression of microstructural changes due to temperature influence
- Material-dependent process strategies

Together with SCHÜTZ+LICHT Prüftechnik GmbH and Middeldorf GmbH, **a prototype grinding machine** was developed that enables the **automated production of flat tensile test specimens.** An integrated cooling system also allows the processing of temperature-critical materials, such as bake-hardening or press-hardening steels. **In combination with the punching of tensile specimens, high-precision test specimens can thus be produced in a cost-effective and time-efficient manner.**



Automated Sample Grinding Machine with Cooled Sample Holders.
Image: gru/utg
Scan the QR code to see the machine in action.

The company Middeldorf GmbH was supported by the Project Management Organization Jülich (PtJ) for the investigations of the process within the scope of the funding code 005-2106- 9177_1720.



Mechanical Deformation | Thermal Influence (Perlite Formation) | No Influence on the Microstructure

Using the example of bake-hardening steel, the results show that the microstructure is not affected by the grinding process, in contrast to the milling or laser cutting processes. Especially from a scientific point of view, we are therefore incredibly pleased to be able to use this equipment to produce tensile specimens at our chair.

New Master Lecture: Successful Innovations - Networks, Financing and Management

In the summer semester of 2022, a new lecture series will focus on questions of knowledge and technology transfer.

The future viability and resilience of national economies are determined more than ever by the ability to innovate in technological, ecological, and social dimensions. **Successful knowledge and innovation systems** make a significant contribution here. Committed researchers drive technology-based ideas in networks of universities, research institutions and the private sector with appropriate funding in a targeted manner for impact-oriented innovations. In this lecture, Dr Sophie Hippmann will explain **how these ideas and research results can be successfully applied and contribute to solving challenges such as climate and demographic change, and what framework conditions are necessary.**

Dr Sophie Hippmann has been Director of Innovation Management at the Fraunhofer-Gesellschaft since 2021. She began her work at Fraunhofer in 2013 as a research assistant to the Fraunhofer President, Prof. Dr Reimund Neugebauer. She then built up the Corporate Think Tank of the Fraunhofer-Gesellschaft. After studying mechanical engineering at the Technical University of Munich, she completed her master's thesis at Rice University in Houston, Texas. From 2006 to 2012 she worked as a research assistant at the *utg* and completed her

doctorate in 2014 with Prof. Hartmut Hoffmann on the topic of "Powder- and melt-metallurgical routes to produce Copper-matrix-CNT-Composites for friction bearings".

Dr.-Ing. Sophie Hippmann, New Lecturer at utg, Image: Fraunhofer Gesellschaft

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Little Feet in Big Safety Shoes - Girls' Day 2022

On Girls' Day 2022, schoolgirls were able to spend a day getting a taste of the everyday research life of female scientists in the field of casting.

Seven schoolgirls between the ages of 11 and 15 spent Girls' Day 2022 at the Fraunhofer IGCV and the *utg*. On this future day, we would like to give girls an understanding of professions in which mainly men have traditionally worked, and in which young women are therefore in great demand. The girls spent the morning of Girls' Day in the foundry technology centre of the Fraunhofer IGCV. At the new location in Garching, they were able to gain insights into sand analysis, microscopy, 3D printing of sand moulds and casting simulation.

On this future day, we would like to give girls an understanding of professions in which mainly men have traditionally worked, and in which young women are therefore in great demand.

Fangtian Deng from the Fraunhofer IGCV shows the Schoolgirls the Possibilities of Microscopy. Image: utg

In the afternoon, what had been shown was then put into practice. The girls were able to mould an owl in sand themselves. Of course, the mould was then cast so that each participant could take home an aluminium owl as a souvenir. The supervisors were delighted with the great interest and the exciting questions. We hope the Girls' Day participants had a wonderful time.

Max Erber from the utg Works with the Girls on Sand Casting. Image: utg

utg News

We Welcome two Scientific Guests

Dr. Liudmyla Lisova

Dr Lisova collaborates with colleagues in the foundry technology department at Fraunhofer IGCV in Lichtenbergstr. 15.

Profile

Nationality: Ukraine

Home Institiution:
E.O. Paton Electric Welding Institute of NASU

Education:
Doctor of Philosophy of Technical Sciences

Age: 35 years

Research focus:
Metallurgy of ferrous and non-ferrous metals and special alloys

Research Project at TUM:
Near-net-shape production of molds from hot-work tool steels using indirect additive manufacturing

Favourite Place in Munich:
English Garden

Prof. Takeshi Nishiwaki

Prof Nishiwaki works at the *utg* with colleagues in the forming department, focusing on material characterizations.

Profile

Nationality: Japan

Home Institiution:
Daido University

Education:
Doctor of Engineering in Materials Processing Engineering, March, 2005 Nagoya University, Japan

Age: 53 years

Research focus:
Sheet metal forming and Material testing

Research Project at TUM:
Identification of yield function parameters from uniaxial tensile tests using Neural Networks

Favourite Place in Munich:
The Isar and English Garden

utg News

12. Kongress Stanztechnik
25. und 26. April 2022
Dortmund

In April 2022, the Stamping Technology Congress organized by KIST e.V. and the *utg* finally took place again in Dortmund's Westfalenhalle. On 25 and 26 April 2022, representatives from industry and research came together to find out about the latest trends in stamping technology.

Photo: KIST e.V.

This year's program focused on the **changes in production and society** under the headings of

- Innovative stamping technology
- Paradigm shifts or phrases
- Strategy for increasing tool life
- Turbulent times

The 14 expert lectures dealt with topics such as sustainability aspects, increasing efficiency and quality, digitalisation, and new products in manufacturing. Prof. Jan Wörner, President of acatech, provided a broader view in his lecture "Digital Transformation - The New Normal" and Carsten Cramer, Managing Director of BVB, with the unusual perspective "More than just a football club - BVB as an economic factor".

Representatives from the industry debated the **current turbulent times** at an overly **exciting discussion** panel. The focus here was on the resulting challenges for companies: from supply bottlenecks to short-time work to social responsibility in times of Ukraine war and the Covid 19 pandemic.

Photo: KIST e.V.

Another focal point at every Stamping Technology Congress is the **excellently presented trade exhibition**. It enabled a close and now again personal exchange with the companies. The **evening event in the BVB stadium** was also used to maintain and establish contacts. It was a great congress with over 250 participants. Everyone was incredibly pleased to make personal contact following the long break.

We are already looking forward to the 13th Stamping Technology Congress next year.

Current Research at *utg*

Forming

New Method for Determining Anisotropic Damage Behaviour

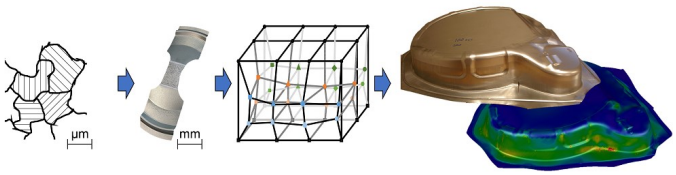
Initial Situation and Goals

Failure prediction following non-linear strain paths is a major challenge in sheet metal forming. Various models have already been developed for this purpose. However, these models are currently limited to non-linear strain paths without a change in the load direction. Within the scope of this project, the influence of the load direction for varied materials is determined together with the Institute for Mechanics and Statics (IMS) of the Universität der Bundeswehr München (UniBwM). This should enable a model to predict material failure after complex strain paths with a change in the load direction.

Solution Approach

A modified Marciniak tool allows the materials to be homogeneously pre-stretched to produce samples. These samples are then examined using various test methods, such as tensile tests, Nakajima tests and nanoindentation. To obtain as accurate a description as possible of the cause of the anisotropic damage behaviour, in-situ X-ray diffraction of tensile tests with pre-stretched samples is also carried out. This determines the material behaviour of individual grains. The tests conducted, allow the investigation of the material structure on a micro and macro level.

The data obtained from this allows the creation of a meta-model that can be used to predict complex non-linear strain paths with a change in load direction.

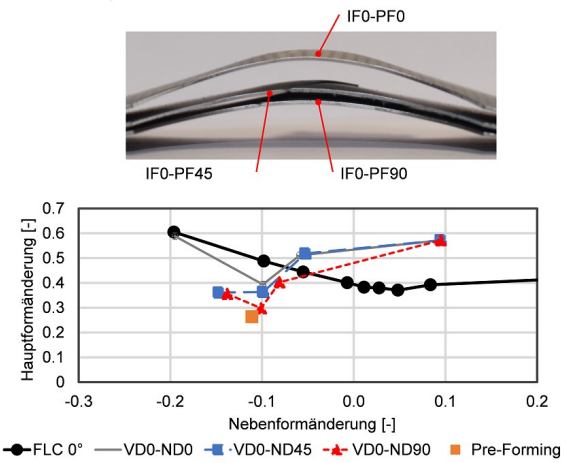


Principle Procedure in the Project, from the Micro to the Macro Level, to the Meta Model and finally to the Application on Real Components

Solution Approach

Initial project results show that steels are particularly prone to anisotropic damage behaviour. The investigated materials CR4, HC340LA, DP600 and HC260Y show an anisotropic material behaviour whereas the aluminium alloy AA6016-T4 shows only a marginal anisotropic damage behaviour. Using commercial FE software, the predictive capability of the 3D-GFLC model could already be demonstrated on a real component.

In the further course of the project, the cause of the occurring damage behaviour is to be investigated more closely. For this purpose, the results of X-ray diffraction (XRD) and the analysis of the fracture surfaces of the Nakajima and tensile tests utilizing scanning electron microscopy (SEM) will be used.



Influence of a Change in Load Direction after Uniaxial Pre-Strain on an HC340LAD

Contact: Roman Norz, M.Sc.

Current Research at utg

Cutting and Punching Technology

Process Induced Residual Stresses

Motivation and Initial Situation

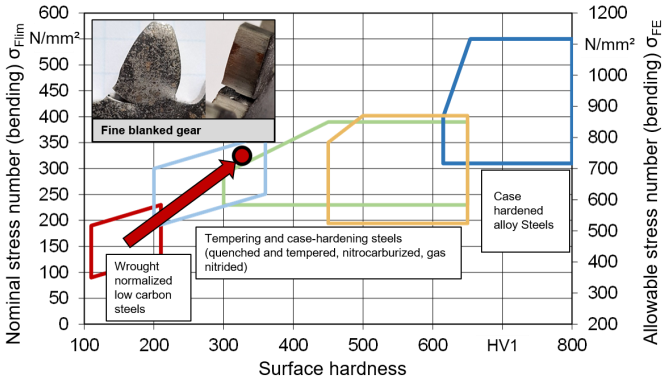
Precision cutting processes (near-net-shape blanking, NNSBV) are one way of producing functional surfaces economically. These cutting processes are accompanied by large plastic deformation and therefore generate residual stresses in the component. Up to now, there have been no approaches to use these forming-induced residual stresses or to introduce their compressive and tensile components in a targeted manner, following a required, component-specific residual stress profile.

This research project aims to develop such an approach together with the FZG of the TUM. In this way, the operational strength of the components is improved without cost-intensive additional operations.

Fine-Cut Gear Wheels (Normal Module: 4.5 mm, Tip Diameter: 82, 45 mm, Tooth Width: 6 mm), Image: utg

Application for Fine Cutting of Gears

In initial investigations, significant differences in the generated residual stress state could be determined depending on the selected method. Five NNSB processes were investigated on components with a circular cutting line geometry. Evidence for an improvement of the fatigue strength due to process-induced residual stresses could also be obtained. The findings were used to produce a gear with involute toothing from the material S355MC by fine cutting. The investigations into the tooth root load-bearing capacity showed that, through the correct choice of the process and the corresponding parameters, it is possible to penetrate areas of the tooth root load-bearing capacity that is otherwise only limited to machined, heat-treated and subsequently ground gears. Here, there is a clear correlation between high tooth root fatigue strength and the high residual compressive stresses introduced.



Strength Diagram according to ISO 6336-5, Image: FZG

Further Focal Points and Outlook

In addition to the investigations of the residual stresses, the project also examines the generated cutting surface parameters, the component deflection, and the hardening near the functional surfaces. The geometric deviations of the gearing surfaces compared to the nominal geometry as well as the surface quality of the functional surfaces are also of interest. In the future, research will be conducted on further gear geometry consisting of a fine-cut pinion/gear pairing. In addition to the tooth root load-bearing capacity, the pit load-bearing capacity will be investigated as an additional design criterion and evaluated regarding the positive influence of residual stresses under realistic operating conditions. The transferability of the findings to the steel of higher strength is to be considered. We are extremely interested in the cooperation with companies for the industrial implementation of the research results.

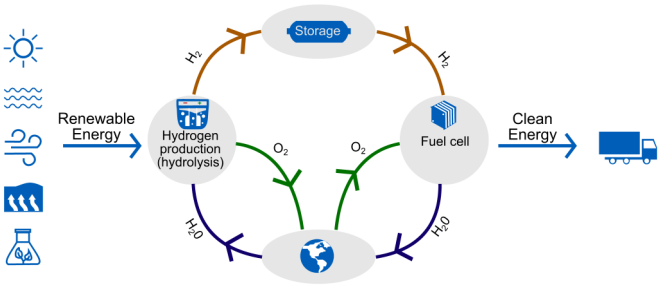
Contact: Anian Nürnberger, M.Sc.

Current Research at utg

Forming

Hydrogen Gas Pressure Vessels for Cryogenic Applications - CryoTruck

Motivation
In Germany, transport accounted for approximately 20 % of the greenhouse gas emissions in 2020. To meet the set targets of the Paris Climate Agreement, drastic decarbonisation is necessary, including the transformation of the commercial vehicle sector towards emission-free drives.



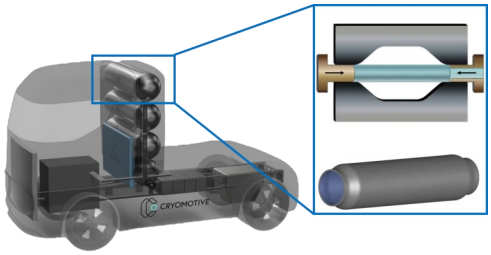
Use of Hydrogen for Emission-Free Fuel Cell Drives, Source: LUXFER

The research project "CryoTruck" is pursuing the implementation of cryogenic storage and refuelling technology in the transport sector to operate fuel cell trucks. The consortium consists of the start-up CryoMotive, MAN Truck & Bus, Clean Logistics, the test experts iABG and the chairs of Carbon Composites (LCC), Plant and Process Technology (APT) at TUM and the *utg*. The goal is to achieve a range of 1,000 kilometres per tank and refuelling in about 10 minutes.

Research contribution of the *utg*
utg concentrates on the design and manufacture of the mobile hydrogen gas pressure tank per the requirements. The tank is an aluminium liner whose outer skin is completely wrapped in carbon fibre reinforced polymer (CFRP). Challenges are the forming of the required pressure tank volumes and the effects of the thermo-mechanical loads on the materials used (aluminium alloy/CFRP) and their interaction with the cryogenic temperature conditions.

Solution Approach
The first goal is to establish a forming process that makes it possible to produce the large-volume hydrogen gas pressure vessels from aluminium. A promising process here is hydroforming (IHU) with seamless tubes as semi-finished products.

Since a hydrogen gas pressure vessel is a safety-relevant component, failure under the specified conditions must be ruled out at all costs. This poses challenges for the materials, which must withstand pressures of up to 450 bar and temperatures of between -150 °C and -230 °C. To be able to make a material selection



Production of the Al Liner using the IHU Process, Source: CryoMotive

that is suitable for the application, the focus of the research is therefore on the construction of a cryogenic material test stand to determine relevant material parameters. In addition, finite element models are to be created to serve the process design and map the thermal and mechanical loads acting on the Type III cylinder during use.

The project started in 2022 and is funded by the Federal Ministry for Digital and Transport.

Contact: Alina Reimer, M.Sc., Edgar Marker, M.Sc.

Personnel at utg

We extend a warm welcome to:

Dipl. oec. troph. **Ulrike Brodbeck** joined the administration on 1 April 2022

Viktor Böhm, M.Sc. joined the Forming Group on 1 April 2022

Edgar Marker, M.Sc. joined the Forming Group on 1 April 2022

We wish her all the best for the future:

Dipl.-Ing. **Isabella Pätzold**, left *utg* on 31 March 2022

Events at *utg*

22 June 2022 Industry Colloquium "Opportunities of Residual Stresses in Forming Technology"

Our industry colloquium offers you the opportunity for information and exchange on the promising possibilities of using residual stresses in forming technology.

Where? TUM Research Campus Garching
Munich Science Congress Center
Walther-van-Dyck-Str. 10
85748 Garching

When? 22 June 2022 from 9.00 am to 4.30 pm

Further information on the programme and registration

Programm and Registrierung

21 July 2022 in-House Exhibition "Sommertreff" at *utg*

We are looking forward to organising another in-house exhibition in 2022. As a special highlight, we will honour the milestone birthday of my esteemed predecessor, Prof. Hartmut Hoffmann. In addition, Dr Roland Golle will end his active time at *utg*. We will also present the plans for his successor. Your Wolfram Volk

Where? Chair of Metal Forming and Casting
Walther-Meißner-Str. 4,
85748 Garching

When? 21. July 2022 from 4.00 pm

To register, please use the following registration link.
Registrierungslink.

Imprint

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Prof. Dr.-Ing. Wolfram Volk (v.i.S.d.P.)

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