Chair of Metal Forming and Casting
Department of Mechanical Engineering
Technical University of Munich

utg Newsletter Issue 4 06/2021

Chair of Metal Forming and Casting

„Those who know a lot ask the right questions.“

Sabine Christiansen (born 1957), German journalist, TV presenter, and producer

Editorial

Dear Readers,

"Good things come to those who wait" is a well-known saying and, in my opinion, it applies to some of the issues we are currently dealing with. Don't worry, I'm not referring to the pandemic and the currently positively developing key figures.

I am very pleased that, with "some" delay, our neighbors in the Science Congress Center Munich were finally able to start operational work on 6 June 2021. I have already been able to get a picture of the new facilities myself and can personally confirm that everything has indeed turned out very well.

Normally, the invitation to our in-house exhibition would also be sent out with this newsletter. Unfortunately, despite all the positive developments, we do not yet see ourselves in a position to invite you to us in good conscience. However, I firmly believe that we will be able to hold a really big celebration in 2022. Our neighbors from the Marriott Courtyard Hotel, have already assured us that overnight accommodation after a pleasant evening together will no longer be a problem.

A second highlight for us is currently the preparation for the CIRP General Assembly. This is also an event that will keep us busy for much longer than originally planned. Let's hope that here, too, a successful event in a unique virtual atmosphere will remain in positive memory.

Apart from that, at *utg* we are constantly switching between a spirit of optimism and crisis management. One of many new experiences was dealing firsthand with the current shortage of raw materials. I can't recall any case in the past where we had to reschedule a research project because no flat steel was available within the project period. In this specific case, we were able to "save" the project by possibly switching to aluminum.

This concludes the short insight into our current challenges. I hope you enjoy reading the newsletter and - as always - I look forward to your comments and constructive criticism.

Prof. Dr.-Ing. Wolfram Volk *Image: Heddergott/*

Stay healthy and hopefully see you soon at *utg*!

Yours

Wolfram Volk

utg News

CIRP General Assembly 2021- virtual from Munich

Back in 2015, the iwb under Prof. Reinhart and Prof. Zäh and the utg under Prof. Volk and Prof. Hoffmann applied to host the renowned CIRP General Assembly in 2020. A six-member administrative team has been deep in the elaborate preparations for the event since 2017. The General Assembly is the international highlight of the conference for production technology: seven days of scientific lectures, countless smaller and larger sessions, three evening events, and an extensive daily accompanying program with excursions and visits require long-term and detailed planning and secure financing.

Then, just over a year ago, the planning of the event came to an abrupt end. The worldwide Corona pandemic completely threw our preparations off course. A postponement to 2021 was unavoidable.

However, due to the still ongoing risk of infection and the international travel restrictions, the 70th General Assembly will not take place in Munich this year either.

With great effort and commitment, we, the local organizing committee, have put together a unique virtual General Assembly. In addition to the paper sessions, there will be a whole range of new opportunities for networking and exchange. Just to mention a few examples: virtual coffee breaks, a birthday serenade for the 70th anniversary, and a virtual hall with fascinating exhibition stands.

Prof. Dr.-Ing. Hartmut Hoffmann, Prof. Dr.-Ing. Wolfram Volk Prof. Dr.-Ing. Gunther Reinhart, Prof. Dr.-Ing. Michael F. Zaeh (from left to right), Image: Sebastian Kissel

We would like to thank all our partners who have accompanied us over the past months and who continue to support the event financially!

https://www.cirp2020.de/corporatepartners/

From 22 to 29 August 2021, we look forward to welcoming many guests from the CIRP community!

New Videos in the Media Library!

After our first, very successful video contribution on “Material characterization at utg,” we have continued to use film in recent months to create a series of new videos. With the professional support of the ProLehre team at TUM, we could film some interesting topics that we now use for our external presentation.

We have also made particular use of the new format in the 2013 Priority Program. A short video is now availab-

le online for each project to allow topics such as "Targeted use of forming-induced residual stresses in metallic components" to be accessible to non-specialists.

Due to the lack of conferences and exhibitions caused by the pandemic, we would like to provide readily accessible insights into research with this new format.

SCAN ME

All videos are now also available in the Technical Information Library TIB in a citable form as Open Access.

This QR code will take you to the vimeo channel of the utg, where you can watch all the films.

Production Engineering for Second Semester

With the new lecture "Introduction to Production Engineering," we offer a bachelor's degree course for Mechanical Engineering and TUM-BWL. The subject was taken up again this summer semester after a break.

In cooperation with the iwb, we teach the basics of developing and designing technical products in this lecture.

Using examples of illustrative components from industrial practice, we look at choosing suitable manufacturing processes, especially in forming and casting. In addition, we show decision-making aids for selecting appropriate materials and rules for production and cost-appropriate design.

Based on this, relevant aspects of production planning are considered, and an outlook on the possible uses of the digital factory is given.

In this course, we primarily want to arouse interest in production technology at the beginning of the bachelor's degree and convey fun in the subject. The initial feedback from the students encourages us in this endeavor.

"I find it very good that it is often explained what the aim of the course and the objectives of the lectures are. The lecturer conveys the content to the students with enthusiasm."

"..., in addition, the lectures are fascinating and well presented, which is why it has become one of my favorite subjects..."

"The excerpts from the documentaries are very helpful in understanding the different casting techniques..."

Excerpt from the Virtual Lecture on Production Technology, Image: utg

In the summer semester of 2021, 480-second semester students from mechanical engineering have taken the module "Introduction to Production Engineering." From 2022 the lecture can also be taken by TUM-BWL students.

Galileo Garching - now open

After many years in the immediate vicinity of the large Galileo construction site, the construction fences have

now been dismantled, the green areas planted, and the parking spaces are also available again.

The new Science Congress Center Munich opened at the same time as the Courtyard-Marriott and the Stellaris Apartment Hotel on 1 June 2021, with a delay of three years. The construction companies were awarded the contract as early as 2008. The groundbreaking ceremony followed in 2014, and there was already a “soft opening” in 2019. We also had to reschedule already planned events at the last minute because the opening was postponed for various reasons. But now, all the noise and hassle are forgotten.

The New Center at the Garching Campus, Image: ©Michael Radeck

Now the low, old utg building ducks into the shadow of the 200-meter-long, 48-meter-wide, and seven-story-high building on the east side of the campus. Although we are now even more out of sight of the Faculty of Mechanical Engineering, we are happy to have friendly new neighbors with a good coffee machine.

In addition to the hotel and the congress center with a spectacular 1,300-seat Audimax, the northern office wing houses many companies and the TUM travel office. TUM will permanently include some of the lecture halls in its room allocation so that many students will also enliven the building and make it part of the campus.

However, we are all looking forward to the planned shopping mall on the ground level with particular anticipation. There will be space for a supermarket, restaurants and other shops. Unfortunately, we will have to wait a little longer for this offer, but the hotel restaurant is also open for outside guests.

The entrance of the hotel is directly opposite the utg, Image: Courtyard-Marriott, Garching

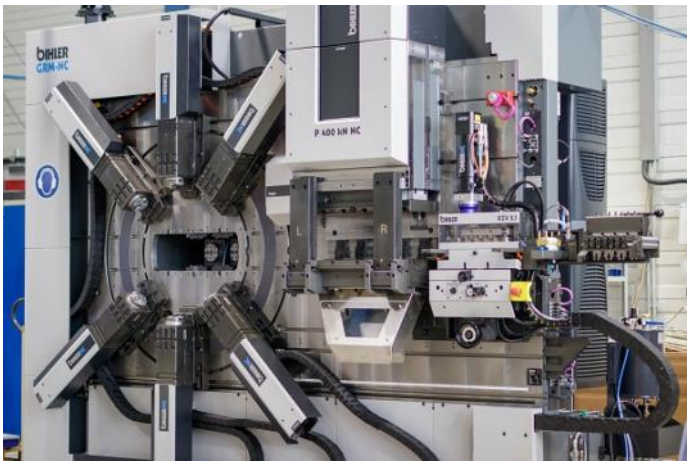
New Bihler Automatic Punching Press

We are delighted to announce that our machine park expanded in April 2021 with a new GRM-NC automatic servo punching and bending machine. We are grateful to Otto Bihler Maschinenfabrik GmbH & Co. KG, Halblech for the press, and it is intended to further advance the research activities at utg.

The stamping and bending machine has a modular design and essentially consists of a gripper feed, a 400 kN servo press, eight independently controllable servo axes - six arranged radially, two in the depth direction - each with a nominal force of 31 kN. The six radially arranged servo units can be freely positioned within their operating range, whereby the adjustment of the units is automated.
In combination with Bihler’s standardized LEANTOOL modular tool system, the system and the tool can be quickly and flexibly adapted to a wide range of different applications.

utg News

The use of servo technology in all essential plant modules offers us a wide range of possibilities for future research projects. For example, a suitable control strategy can be used to adjust stroke parameters during the production process to compensate for deviations from the component's nominal geometry due to batch fluctuations in the sheet metal material used. The development and implementation of such a control loop are to be done in close cooperation with the Bihler company.



The new Stamping and Bending Machine from Bihler at utg, Image: sis/utg

In addition to possible future research topics, the new punch-bending machine is already being used to carry out experimental investigations in single and continuous strokes as part of the EFB research project "Avoidance of upturned punch slugs by influencing slug friction."

In addition to its use in research, the new facility is also crucial in the training of young scientists. In student work such as bachelor's, semester, or master's theses, future engineers can be introduced to the possibilities of NC servo technology.

Measurements at the German Electron Synchrotron DESY

We have been working closely with the team at the Munich Research Reactor (FRMII) for many years. Under the responsibility of Dr. Joana Rebelo-Kornmeier (FRMII) and Simon Vitzthum (utg), a DFG-funded cooperation project investigates the elastic and anelastic deformation behavior of forming steels.

In this rather basic research, macroscopic and microscopic material parameters are to be determined and correlated to improve existing models for FEM simulation. For this purpose, cyclic tensile and compression tests are necessary to measure the macroscopic force and strain and the sample temperature parallel to the microscopic strains and dislocation densities.

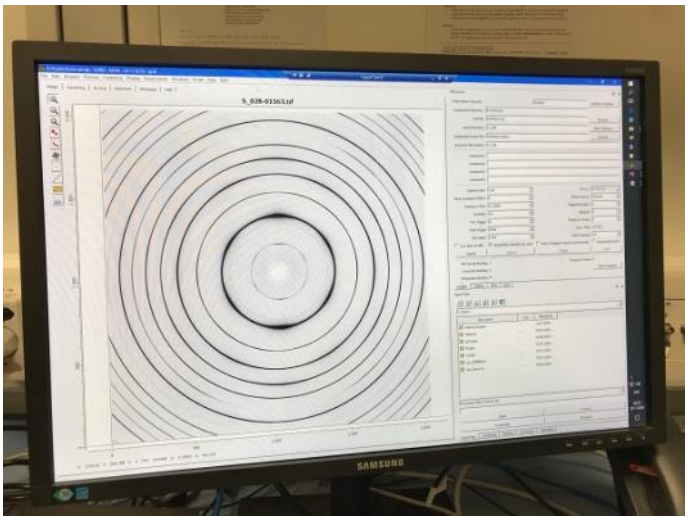
The Home of the Petra III Instrument at DESY, Image: utg

In addition to neutron diffraction at FRMII in Munich, high-energy x-ray radiation from DESY in Hamburg also offers the possibility of recording microscopic parameters. Since x-ray radiation has several advantages over neutron radiation, such as a faster measurement frequency, measurements at DESY offer a high added value for scientists.

In November 2020 and April 2021, we were provided several days of measurement time at DESY's Petra III measuring instrument.

utg News

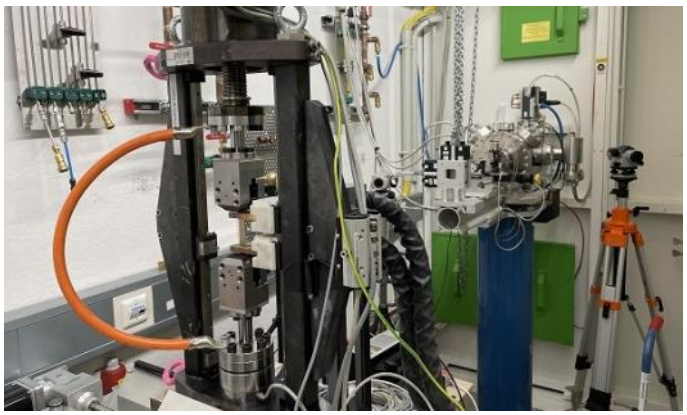
The FRMII tensile test stand, which was dismantled in Munich and rebuilt in Hamburg, served as the test stand. The test setup and the measurement procedure at DESY made it possible to measure x-ray transmission during the tensile and compression tests.



X-Ray Diffraction Profile of the Transmission Measurement at DESY, Image: utg

In this way, it was possible to record x-ray diffraction profiles synchronously to the measurement of the macroscopic parameters.

To use the precious measuring time as efficiently as possible, the colleagues worked around the clock in shifts to examine as many different test methods and measurement settings as possible.



Tensile Test Rig with Conductive Heating, in the Background the X-Ray Tube, Image: utg

This allowed Maximilian Gruber (utg) and Dr Weimin Gan (HZG) to carry out further preliminary investigations for a planned research project in the field of superplastic forming. Conductively heated tensile tests were investigated here to shed light on the underlying mechanisms of the high-temperature forming process and thus draw conclusions for industrial use.

In total, we were able to carry out about 100 tests and the first results show that the measurements have a great added value for both research projects.

Due to the complexity of the evaluation of the diffraction profiles and the large amounts of data, a detailed evaluation will still take some time.

Before heading home, the research team was treated to a small reward at Hamburg harbor after the exhausting 24-hour shifts.

Image: utg

Latest research news at the *utg*

Casting

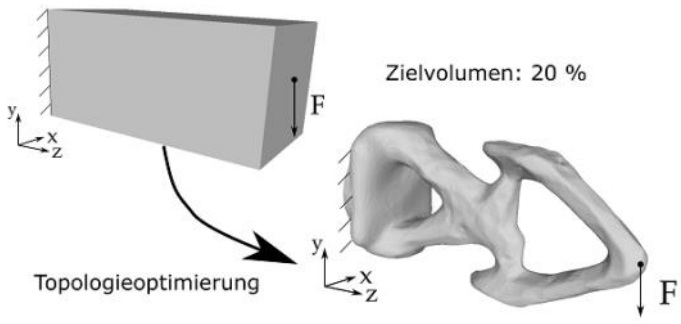
Replacement Models for Casting Processes

Motivation

In recent years, the use of load-oriented optimization (topology optimization) has become established in the design of cast components. Components developed in this way offer the advantage of a lower component weight with consistently high stiffness and strength. The standard optimization software for the actual casting process is currently only taking into account simple manufacturing restrictions such as minimum wall thicknesses, draft angles, or the avoidance of undercuts. Consequently, integration of more extensive knowledge of the casting process is insufficiently mapped.

With the current state of the art, this means that topology optimization and casting simulation have to be carried out alternately. This iterative procedure is associated with high personnel and time costs.

The aim of this project is the automated integration of simplified, geometric evaluations of the casting process in the optimization. This generates components that on the one hand have a low weight and high stiffness and on the other hand can still be produced as a cast component.



Initial Volume of a Cantilever Beam for Load-Compliant Optimization and Optimized Cantilever Beam as a Low-Pressure Casting Component, Image: utg

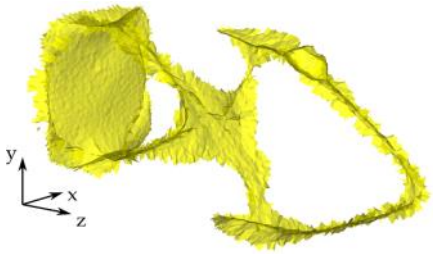
Solution Approach

Analogous to a common casting simulation, the geometric evaluation of a component is also carried out based on the solidification behavior and based on the filling behavior with melt.
The substitute models should approximate the exact solution of casting simulations sufficiently accurately with short calculation times.

Assessment Models

For the evaluation of the solidification, the local component thicknesses and cross-sections are used. For this purpose, the three-dimensional problem for the evaluation of a solid is simplified to a problem for the evaluation of a surface model (see Image 2). The model is based on the center surfaces of the component and is then evaluated using graph theory algorithms.

One way to evaluate the filling process is to model it using cellular automata. In these models, the flow behavior of fluids is based on simple, discrete rules in individual cells of a finite volume mesh.



Surface Model of the Component Center Surfaces using the Medial Axis Transformation, Image: utg

Results and Outlook

In initial trials, the casting process was integrated into the topology optimization through casting simulations. In these preliminary tests, it was already possible to optimize the component geometry using different process variables (solidification or filling). In the further outlook of the project, these process simulations will now be replaced by faster geometric substitute models to reduce the computing time.

Contact: Maximilian Erber, M.Sc.

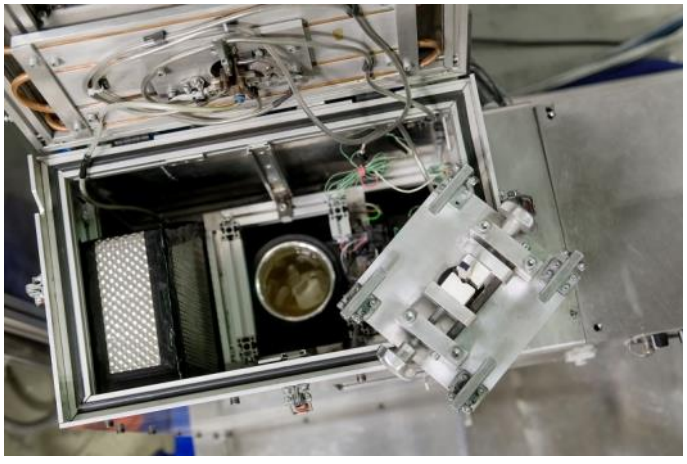
Latest research news at the *utg*

Cutting

Reduction of Cold Welds

Initial Situation
Cold welds are one of the biggest challenges in sheet metal processing. To counteract these, lubricants and coatings are currently used in the industrial environment, the choice of which is based on experience or the trial-and-error method.

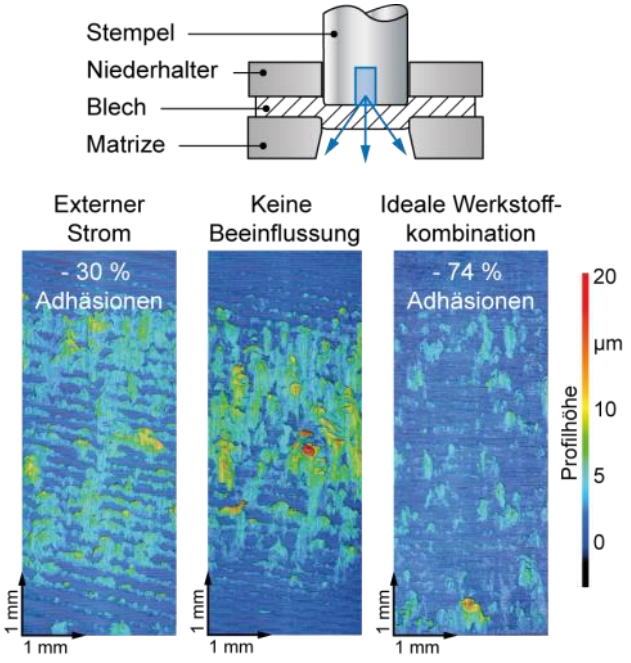
Thermoelectricity and Adhesive Wear
At utg, in addition to the process temperature, another decisive influencing factor on adhesion formation could be identified, thermoelectric currents. These arise due to the Seebeck effect in every type of sheet metal processing. The amount of cold welding on the tool side depends primarily on the strength and direction of the thermocurrent that is generated, which in turn is mainly determined by the thermoelectric behavior and thus the Seebeck coefficient of the tool and sheet material. Since knowledge of this is essential for reducing wear, utg has a unique measuring device that enables the Seebeck coefficients of all electrically conductive materials to be determined.



View into the Measuring Apparatus for Determining the Material-Specific Seebeck Coefficient, Image: Tobias Hase

Application for Wear Reduction
The utilization of these findings can be achieved on the one hand by the suitable selection of the material combination tool/sheet and on the other hand by a process-specific external current, which is introduced into the contact zone between punch and sheet.

While in the first case an ideal combination largely prevents the formation of natural thermal currents, in the second case the external current counteracts them. As a result, adhesion formation is inhibited, which drastically reduces cold welds on the tool. Overall, their quantity on the punch surface during shearing and forming could be reduced by up to 74 %. The use of both wear reduction strategies can be used in existing and future forming and shearing tools and have already been successfully tested in an industrial environment.



Characterization of the Cold Welds on the Punch Shell Surface during Dry Shear Cutting with and without the Influence of Thermoelectric Currents [Tröber et al., Dry Met. Form. Journal 6, 2020].

Contact: Philipp Tröber, M.Eng.,
Markus Welm, M.Sc., Agnes Schrepfer, M.Sc.

Latest research news at the *utg*

Forming

Fiber Beads: Lightweight Construction through Hybrid Beads

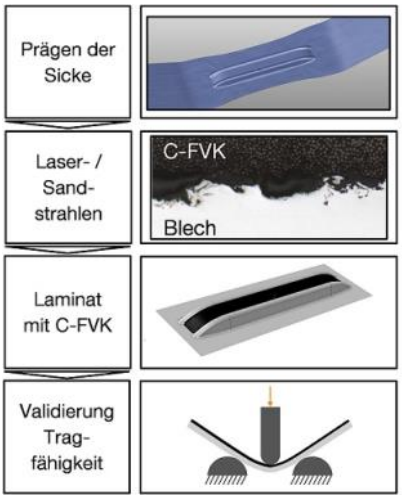
Motivation
Beads are channel-shaped load support structures in sheet metal components. By cleverly placing the beads in the component, the mass-specific stiffness can be significantly increased, as illustrated by the example of an oil pan.

Achievable Mass Reduction of an Oil Pan through Beading with the same Component Stiffness, Image: utg & IPEK

In the DFG research project Fiber Beads at utg, structural lightweight construction using beads is combined with a multi-material construction method: For this purpose, a reinforcement made of carbon-fiber-reinforced plastic (C-FRP) is applied to the bead cross-section. The resulting increase in the area moment of inertia further increases the bending stiffness of the component.

Solution Approach & Results
To prove the achievable stiffening effect of the beads, a complete manufacturing process is worked out and run through: As shown in Image 2, this includes the embossing of the bead, a surface structuring, and the lamination with the CFRP reinforcement.
The structuring by laser or sandblasting serves to increase the surface roughness of the sheet and increases the composite strength of the hybrid component. By aligning the fibers along the bead axis, the anisotropic material properties of the composite are exploited.

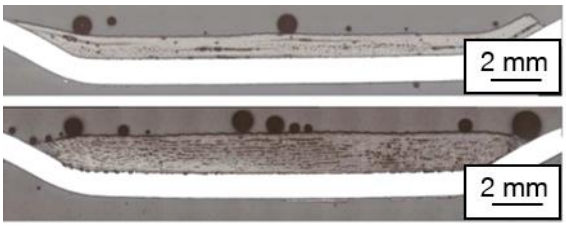
The stiffening effect of this hybrid bead is quantified by bending tests and modal analysis. Depending on the



Steps for manufacturing and validation of the Hybrid Beads, Image: utg & IPEK

number of fiber layers used, a significant increase in the maximum load that can be absorbed is measured. Furthermore, it should be made possible for users to adopt the hybrid beads as easily as possible in their products. To support the design process, a numerical algorithm is being developed in collaboration with the Institute for Product Development (IPEK) at KIT Karlsruhe. With this, an optimized alignment of the beads in the component is achieved based on the main bending stresses that occur.

The validation results on the examined prototypes show that an application of the hybrid beading for small series with lightweight construction requirements is reasonable and technically feasible.



Different Degree of Stiffening of the Bead Cross-Section by varying the Number of Layers of the C-FVK Reinforcement, Image: utg & IPEK

Contact: Michael Ott, M.Sc.

Personalia at the *utg*

Wir extend a warm welcome to:

Julika Hoyer, M.Sc.
Joined the Casting Group on 1 March 2021

Katja Holzer, M.Sc.
Joined the Forming Group on 1 June 2021

We wish them all the best for the future:

Dr.-Ing. **Florian Heilmeier**
left *utg* on
31 January 2021

Thomas Greß, M.Sc.
left *utg* on
31 March 2021

Jens Stahl, M.Sc.
left *utg* on
30 April 2021

New Dissertations at *utg*

28 **Hartmann, Christoph**: Spatio-Temporal Optical-Flow Methods for Process Analysis, December 2020

29 **Raupach, Marco**: Simulationsbasierte Konstruktionsmethodik zur Herstellung markanter Bauteilradien im Karosseriebau, April 2021

30 **Zgoll, Fabian**: Methodik zur optimalen Werkzeugeinarbeit, May 2021

31 **Lechner, Philipp**: A Material Model for Foundry Cores – The Brittle Fracture Behaviour of Chemically-Bound Foundry Cores, June 2021

All publications and dissertations of the chair are listed on the website www.utg.de

The dissertations are published as print-on-demand in **Schriftenreihe Umformtechnik und Gießereiwesen**, Hrsg. Prof. Dr.-Ing. W. Volk, TUM University Press, ISSN: 2364-6942

Imprint

The *utg* Newsletter is published twice a year and is edited by

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