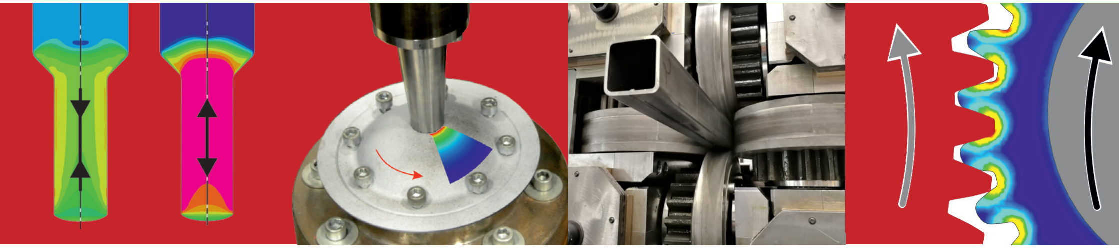


Institute of
Forming Technology and
Lightweight Components

Activity Report

19

technische universität
dortmund

Institute of
Forming Technology and
Lightweight Components

Activity Report

19

technische universität
dortmund

Imprint

Institute of Forming Technology and Lightweight Components
TU Dortmund University
Baroper Str. 303
44227 Dortmund
Germany
Phone +49 (0) 231 755 2660
Fax +49 (0) 231 755 2489
www.iul.eu

Prof. Dr.-Ing. Dr. h.c. Matthias Kleiner
Prof. Dr.-Ing. A. Erman Tekkaya

Editor
Prof. Dr.-Ing. A. Erman Tekkaya

Editorial assistance
Nina Hänisch

Editing
Jeanette Brandt
Nina Hänisch
Beate Ulm-Brandt

Layout
Patrick Cramer

Inhalt

Preface

The Institute of Forming Technology and Lightweight Components continued to pursue its internationalization strategies in 2019. Being a member of the global research community, it goes without saying that our research tasks do not end at national borders. Therefore, our goal must be to further expand research networks across national borders at all levels: The IUL organized short visits and lectures of top-class guest speakers from renowned universities such as Frédéric Barlat, Kaan Inal, and Christopher Saldana, invested in the maintenance of long-term research collaborations with colleagues from universities such as Xi'an Jiatong University and institutes such as the "Instituto Superior Técnico" of the Technical University of Lisbon, and in cooperations with large international companies such as Baoshan Iron & Steel, KOBE STEEL, and Faurecia. The IUL organized exchange programs for students with partner universities, for example with the Ohio State University and Gifu University, and attracted international grants such as the Gambrinus Fellowship or the DAAD's RISE and Erasmus grants. We are very proud that a total of 12 renowned guests from 7 nations accepted our invitation to visit the IUL in 2019. The chapter "International exchange" of this activity report provides you with a deeper insight into our internationalization activities.

Another focus of the year was the re-accreditation of the mechanical engineering, industrial engineering, and logistics courses and, thus, all IUL courses. The IUL used this occasion as an opportunity to implement current research results and innovative teaching and learning concepts for academic training from the ELLI 2 project, a joint project of engineering chairs with university didactic facilities, in the curriculum, thus further improving the quality of teaching at the IUL. For example, a new course on "Material Characterization in Forming Technology" was introduced which combines elements of teaching theoretical basics in the form of online self-study with attendance appointments and the independent conduct of remote and hands-on experiments and their evaluation. In addition, extensive changes were made in the examination regulations and in the module handbooks: courses were structured more consistently, lectures regarding the sequence of the manufacturing processes were restructured thematically, meaning that they are being based on each other or combined. The close cooperation of the institute with representatives from industry in various committees such as the IUL industrial advisory board and in research centers such as ReCIMP also ensures that students can apply the knowledge they have gained through practical research and imparting soft skills, making them well prepared for their later work environment.

In Transregio 188, too, we attach great importance to the feedback from industry representatives. As part of an industrial colloquium, the Transregio industrial group was invited to develop new applications for the topic of "damage" which was discussed there. This valuable exchange was also continued as part of a mini-symposium on the subject of "Ductile damage in forming technology" at Numiform 2019 in the USA. The great response shows the relevance of the topic for both the scientific and industrial community.

The compactly summarized results and progress of all projects worked on by the IUL team are provided in this report. As an example, the results of the research centers are mentioned here: Last year, research in the area of the combination of additive manufacturing and forming technology was further expanded in the Research Group on Additive Technology (ReGAT). Two further applications submitted to the DFG were approved so that three research projects are currently located in this subject area: the two-point incremental forming with subsequent additive manufacturing of functional elements, the development of novel tools combining layer-laminate-manufacturing and laser-powder-deposition, and the burnishing of additively manufactured forming tools. The successful work in the ReCIMP research center was continued as well. In particular, it was investigated which methods can be used to characterize modern materials – precisely adapted to the respective metal forming manufacturing process.

We would like to thank all partners of the institute and the IUL team for the great cooperation and end this preface with an outlook on 2020, in which we can look forward to two great conferences organized by the IUL: The eighth "Dortmund Tube and Profile Bending Colloquium" deals with the networked production of tube and profile components with a special focus on sensors and actuators for the detection and correction of bending errors. The ninth "International Conference on High Speed Forming" will present research results on the topics of "process technologies", "tools and equipment", "energy, materials, and measurement technology", "modeling and simulation" as well as industrial applications of high-speed forming. Further information on the conferences and current news from the institute can be found online at **www.iul.eu**.

A. Erman Tekkaya

Matthias Kleiner

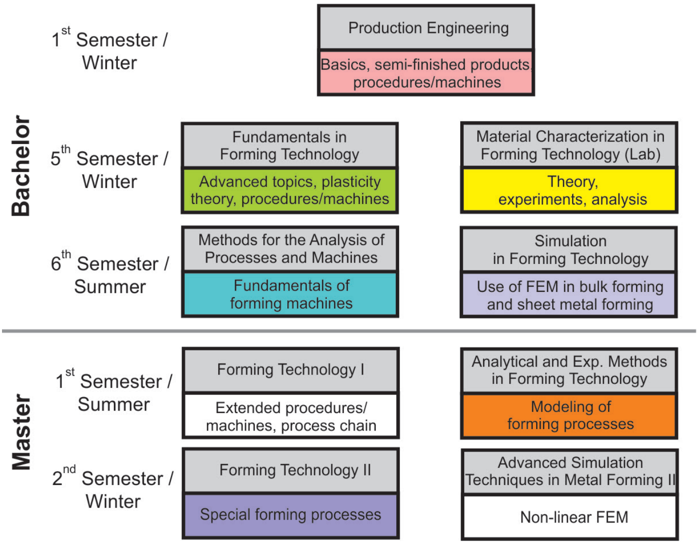
Education

01

1 Education

1.1 Offered Courses

The Institute of Forming Technology and Lightweight Components offers lectures and laboratories in the following bachelor and master programs: logistics, industrial engineering, and mechanical engineering. In addition, students of computer science, physics and those studying to become teachers attend the courses offered by the institute as part of their minor subject. The students acquire knowledge in the field of forming technology that is necessary in order to succeed in the industrial working environment or to enter an academic career. Since winter semester 2019/2020 the following structure of lectures is applicable due to the reorganization of the examination regulations:



Structure of lectures for the study program mechanical engineering with a specialization in production engineering (after accreditation 2019)

Other courses offered by the institute in 2019 were:

- Lecture series on forming technology
- Laboratory work A as part of the Master's Program in Mechanical Engineering
- Laboratory work B as part of the Bachelor's Program in Industrial Engineering

The following courses are offered in English as part of the international master's program "Master of Science in Manufacturing Technology (MMT)":

- Forming Technology I – Bulk Forming
- Forming Technology II – Sheet Metal Forming
- Advanced Simulation Techniques in Metal Forming
- Additive Manufacturing
- Aluminum – Basic Metallurgy, Properties, Processing, and Applications
- Laboratory Work – Material Characterization

In cooperation with the KARL-KOLLE-Foundation and organized by the ELLI 2 team the third workshop focusing on 3D printing in schools took place at the IUL. In 2019, the workshop was tailored to the needs of teachers in order to enable them to apply the technology in their teaching. The workshop was designed for several school subjects: technology, computer sciences, and physics, but also sports, arts, and geography. Besides the basics of the hard-

Group of teachers with the organizer of the workshop J. Grodotzki (in the rear, left), the head of the institute Prof. Tekkaya (right), and the chairman of the Karl-Kolle-Foundation Prof. Pinninghoff (second from right)

ware, the entire processing route comprising all steps on the software level was taught. Now, these teachers can spark their students' interest in this technology.

In 2019, the following guest lecturers have contributed to the course offer at the IUL:

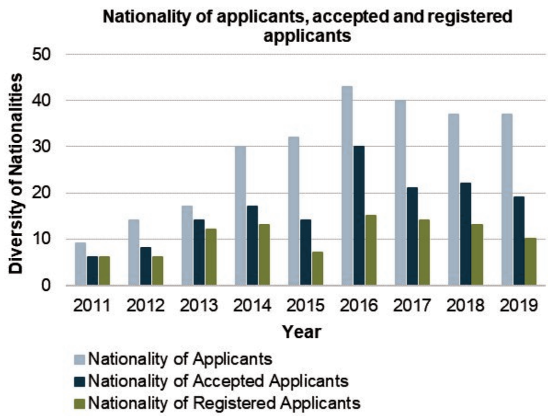
- Prof. P. Haupt, Emeritus Professor from the University of Kassel
- Prof. J. Hirsch, Hydro Aluminium Rolled Products
- Prof. K. Roll, formerly Daimler AG Sindelfingen
- Prof. J. Sehrt, Ruhr-University Bochum

For further information, please visit: **www.iul.eu/en/teaching.**

1.2 Master of Science in Manufacturing Technology (MMT)

Coordination — Prof. Dr.-Ing. A. Erman Tekkaya
Frigga Göckede B. B. A.
Nena Amponsah B. A.
Anna Komodromos M. Sc.

The English-taught, four-semester study program 'Master of Science in Manufacturing Technology', which started in 2011, was again of much interest to international students regarding the start of studies in winter semester 2019/20. 24 carefully selected and excellent students out of around 800 applicants from 37 nations have begun their MMT studies in Dortmund. Within the scope of the cooperation with the Turkish-German–University in Istanbul, organized by the German Academic Exchange Service (German: DAAD), one student from Turkey started his MMT studies.



Diversity of nationalities of applicants, accepted and registered applicants

Visit of the EAIE conference 2019 in Helsinki (Ms. Amponsah, MMT, and Ms. Artmann, Int. Office)

In order to further increase the diversity of the MMT program, the coordination team analyzed the countries of origin of the students and, on this basis, took steps to inform more students from other countries about the study program.

In this context, newsletters were sent out, webinars were offered, and ads were placed in cooperation with the DAAD in order to draw attention to the program and the application period. Furthermore, the coordination team visited the EAIE conference on the internationalization of higher education in Helsinki, with more than 6,000 participants, in order to gather ideas for strategy development in the field of international affairs. In addition, the coordination team will take part in the EDUEXPOS fair in Milan, where prospective students receive information and personal advice.

Welcome event for the MMT batch 2019

The MMT online application portal has qualitatively improved in cooperation with the IT & Media Center of TU Dortmund University. Hence, the application procedure for the applicants as well as the processing of the applicant's data and the subsequent selection of the students to be admitted have become even more convenient and efficient.

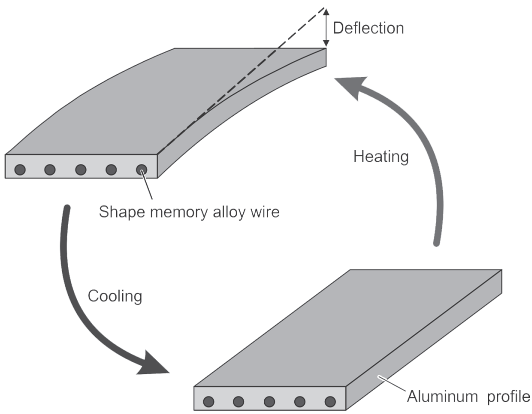
Before the start of the lecture period the new MMT students were welcomed by Professor Tekkaya as head of the MMT program within the scope of a welcome event in the lecture hall of the Mechanical Engineering Building MB III. After the reception the students were able to inform themselves about the modules and projects of the chairs and institutes involved and to attend a poster session at the get-together.

Further information can be found at **www.mmt.mb.tu-dortmund.de.**

1.3 Doctoral Theses

Dahnke, Christoph	Adaptive Lightweight Components Made of Aluminum and Shape Memory Alloys Manufactured by Composite Extrusion
Original title	Verbundstrangpressen adaptiver Leichtbau-komponenten aus Aluminium und Formgedächtnislegierungen
Series	Dortmunder Umformtechnik, Volume 105
Publisher	Shaker Verlag, Aachen, 2019
Oral exam	February 12, 2019
Advisor	Prof. Dr.-Ing. A. E. Tekkaya
Co-examiner	Prof. Dr.-Ing. G. Eggeler (RUB)

Composite extrusion represents a flexible possibility for the manufacturing of composite profiles with embedded shape memory alloy wires. By means of a targeted positioning of the wires as well as a further processing it is possible to produce adaptive lightweight profiles. During a thermal activation these profiles are capable of carrying out a bending function or significantly changing their mechanical properties as a reaction to the temperature increase. The results of the work show that due to the high pressure, combined with the high temperature during the extrusion process, a metallurgical bond can be achieved between both composite partners. The strong metallurgical bond is able to transfer the stresses which are generated by the shape memory alloy wires to the matrix. In case of an eccentric position of the wires, the generated bending moment depends on the geometrical dimensions of the profiles as well as on the activation stress of the wires.

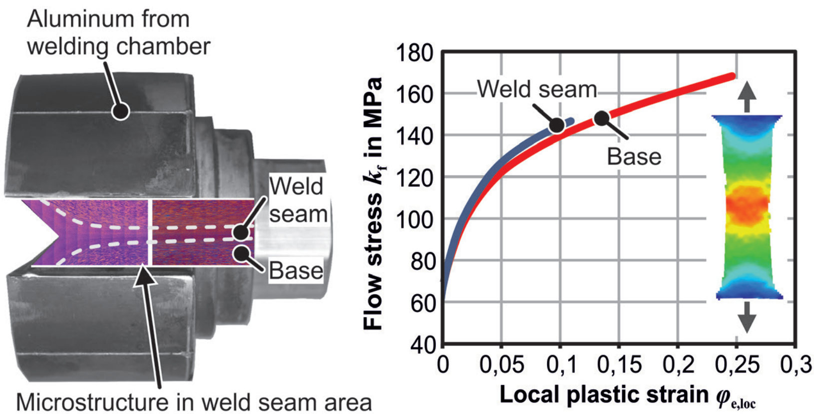


Adaptive lightweight profile with bending function

Schwane, Martin	Formation and Properties of Longitudinal Weld Seams in Aluminum Hot Extrusion
Original title	Entwicklung und Eigenschaften von Längspressnähten beim Aluminiumstrangpressen
Series	Dortmunder Umformtechnik, Volume 107
Publisher	Shaker Verlag, Aachen, 209
Oral exam	July 23, 2019
Advisor	Prof. Dr.-Ing. A. E. Tekkaya
Co-examiner	Prof. Dr.-Ing. habil. Dipl.-Math. B. Awiszus (Chemnitz University of Technology)

In the common process variant of hot extrusion using porthole dies longitudinal weld seams are generated. The aim of this thesis is to contribute to a further understanding of the formation and development of the mechanical properties of longitudinal weld seams.

The relevant parameters for the solid state bonding process were identified by means of a newly developed model test rig. A phenomenological welding model was derived for the quantitative description of the observed interrelations. This model was subsequently used to estimate critical welding conditions in the process-related investigations. As a result of the extrusion trials, deviating mechanical properties between the weld area and the base material were quantified. The influence of both the die design and the heat treatment on the final properties was comprehensively analyzed in further investigations.

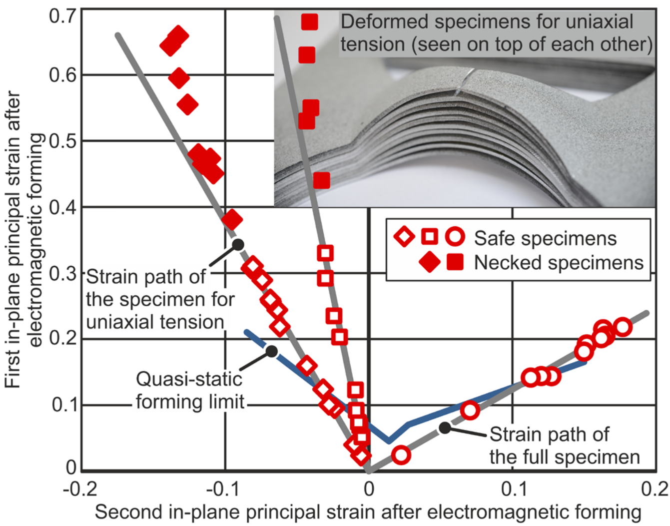


Characterization of the weld seam-related inhomogeneity of the microstructure and of the mechanical properties

Demir, Osman Koray	New Test and Interpretation of Electromagnetic Forming Limits of Sheet Metal
Series	Dortmunder Umformtechnik, Volume 106
Publisher	Shaker Verlag, Aachen, 2019
Oral exam	August 26, 2019
Advisor	Prof. Dr.-Ing. A. E. Tekkaya
Co-examiner	Prof. Dr. G. Daehn (The Ohio State University)

A new method is proposed to determine the electromagnetic forming limits of sheet metal. The method includes a new specimen concept that ensures deformation on a constant strain path and failure at the apex. The method is used to find the electromagnetic forming limit curves for AA1050A, AA5083, and Mg AZ31 sheets. These materials exhibit higher forming limits in the electromagnetic forming, when compared to quasi-static forming. In addition, in electromagnetic forming the limits increase with the strain rate.

In order to explain the higher limits in electromagnetic forming, fracture surfaces of quasi-static and electromagnetic samples are examined. These suggest the existence of out-of-plane shear stress in electromagnetic forming. According to Allwood and Shouler (2009), out-of-plane shear stresses increase the forming limits in quasi-static tensile tests. This dissertation proposes out-of-plane shear stress as a reason for the higher limits in electromagnetic forming.



Electromagnetic forming limit tests on three different strain paths (Material: AA1050A-H24, 1 mm thick)

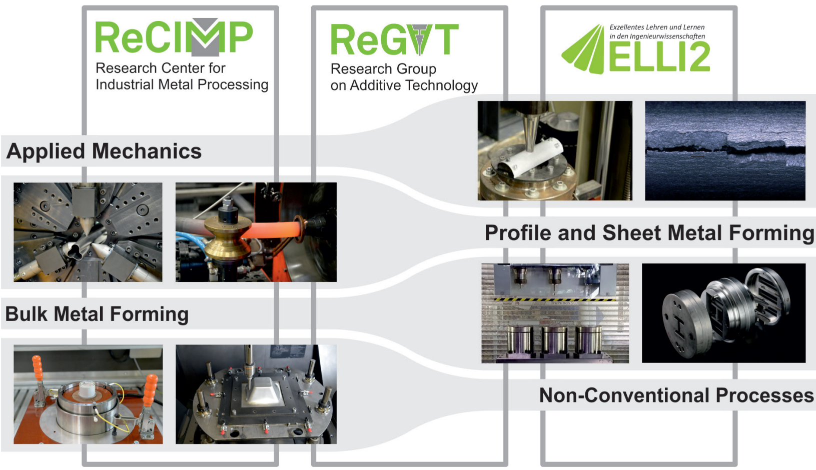
Research

02

2 Research

The research activities of the Institute of Forming Technology and Lightweight Components comprise the development of new forming processes and process chains as well as the extension of existing production processes. Key objectives are the achievement of a physical process description, the configuration and improvement of component properties, and a holistic approach of the process efficiency. The primarily fundamental questions are supplemented by aspects of applied research to ensure the quickest possible transfer of research results to industrial practice.

35 scientists, who are supported by 12 technicians and administrative staff members, and approximately 50 student assistants work on the institute's research projects. Especially as regards interdisciplinary research issues, the projects are often processed with national and international partners. The participation in two "Collaborative Research Centres", TRR 188 (spokesperson) and TRR 73 (local spokesperson), and in the two "Priority Programmes", SPP 1640 und SPP 2013, express this intensive networking. Besides the four departments "Applied Mechanics in Forming Technologies", "Bulk Metal Forming", "Profile and Sheet Metal Forming", and "Non-Conventional Processes" the institute structure (see figure) covers three inter-divisional units: "Research Center for Industrial Metal Processing" (ReCIMP), "Research Group on Additive Technology" (ReGAT), and "Excellent Teaching and Learning in Engineering Science" (ELLI 2). In the following, the department-specific research objectives and research projects are presented.



Institute structure

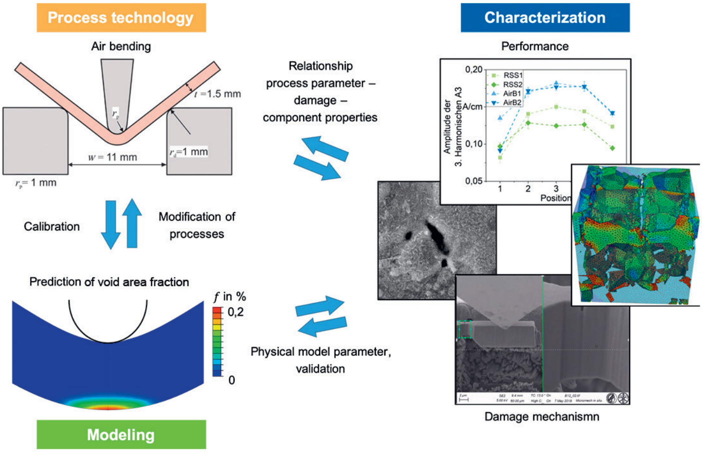
2.1 Research Groups and Centers

2.1.1 Collaborative Research Center Transregio 188 – Damage Controlled Forming Processes

Funding	German Research Foundation (DFG)
Project-ID	CRC 188/1-2019
Spokesperson	Prof. Dr.-Ing. A. Erman Tekkaya
Managing Director	Dr.-Ing. Frauke Maevus

The Collaborative Research Center TRR 188 aims at fundamentally understanding the damage mechanisms during forming and their effects on product properties in order to be able to predict the damage quantitatively and adjust it specifically with regard to component performance. Starting point is the observation that different process routes for the manufacturing of a forming component from a given semi-finished product lead to the same final geometries, but different properties and damage. Thus, it is basically possible to influence the damage evolution along the forming process chain from the semi-finished product to the finished component by selecting and designing the forming processes. If not only the nominal material properties are used in the design, but the damage caused by the forming process is taken into account in the same way as other production-induced properties, this leads to a paradigm shift in both process and component design. Instead of a process design based on the manufacturability or the maximum failure-free formability of the material ("formability"), there is a "damage-based" process design that pursues a failure analysis with regard to the use of the component and the achievement of maximum performance ("usability"). When dimensioning the components, the targeted adjustment and precise quantification of the damage level enables a significant reduction in safety factors. As a result, novel lightweight products can be realized which are characterized by a reduced mass compared to the state of the art, at the same time guarantying the functional reliability of the components during the utilization phase.

To achieve this goal, an interdisciplinary consortium of production engineering, material science, materials testing technology, and mechanics develops new methods and technologies for a quantitative prediction (project area "Modeling"), assessment (project area "Characterization"), and control (project area "Process Technology") of the damage, taking into account the material-physical relationships.



Project areas of the TRR 188

The indispensable prerequisite for a damage-based design of forming processes are powerful modeling approaches that can map the underlying microscopic damage mechanisms and predict the properties of components manufactured by forming technologies including the damage. Since there are no generally applicable approaches for any forming processes and process sequences so far, new theoretical model approaches at meso/micro and macro level are developed in TRR 188.

For the development and validation of these models, the physical damage mechanisms located on different length scales must be precisely resolved. To characterize these mechanisms, innovative and high-resolution measuring methods, such as in-situ testing technology in electron microscopy, are used. Since the ductile damage is usually dispersed in the material volume, additional alternative methods which can characterize the damage states non-destructively in the material volume are tested. To evaluate the component's performance at the macro level, modified load increase tests are used to characterize and quantify the interaction of ductile and cyclic damage mechanisms.

The prerequisite for the control and targeted adjustment of the damage is knowledge of how the load paths can be influenced in the various sheet metal and bulk forming processes and how these load paths affect the damage. In addition, the influence of the forming history on the damage development along the process chain must be determined in order to be able to make statements about the accumulated damage in the finished component and the resulting component properties. The characterization methods mentioned above are used to investigate the initiation and development of damage as well as the relationships between process parameters and the resulting state of damage. The modeling methods for the quantitative prediction of the damage provide important clues for the development of damage-controlled processes.

The basis for the joint, interdisciplinary development of methods and technologies is a precise definition of damage and its mechanisms. As the literature shows, the different disciplines use different definitions and terms. Therefore, the TRR 188 has set itself the task of developing a comprehensive, uniform understanding of damage and making it publicly accessible in the form of a basic lecture. In addition to this lecture, the various other research results of the TRR 188 were presented and discussed at scientific and industry-related symposia in the national and international environment. These included CIRP, ICTP, ECCM, IDDRG, ESAFORM, GAMM, MSE, various DVM working group meetings, and the 1st Industrial Colloquium organized by TRR 188 in Dortmund.

The research is carried out by scientists from TU Dortmund University (Coordinating University) and RWTH Aachen University. Specifically, the Institute of Forming Technology and Lightweight Components (IUL), the Institute of Mechanics (IM), and the Department of Materials Test Engineering (WPT) from the Faculty of Mechanical Engineering in Dortmund are involved as well as the Chair of Structural Mechanics (BM) from the Faculty of Architecture and Civil Engineering. At RWTH Aachen University, the participating institutes are the Metal Forming Institute (IBF), the Steel Institute (IEHK), and the Institute of Physical Metallurgy and Metal Physics (IMM) from the Faculty of Georesources and Materials Technology as well as the Laboratory for Machine Tools (WZL) from the Faculty of Mechanical Engineering and the Central Facility for Electron Microscopy (GFE). In addition, there is the Chair of Mechanical Design and Manufacturing at BTU Cottbus-Senftenberg and the non-university institute Max-Planck-Institut für Eisenforschung GmbH (MPIE) in Dusseldorf. The interdisciplinary consortium is supported by an industrial advisory board counseling the TRR 188. The research association receives important impulses for further research activities by the experiences and suggestions from industrial practice.

2.1.2 ReCIMP – Research Center for Industrial Metal Processing

Head Dr.-Ing. Dipl.-Wirt.-Ing. Jörn Lueg-Althoff

The cooperation with the international automotive supplier Faurecia, which has now been established for six years, was successfully continued in 2019. In the Research Center for Industrial Metal Processing (ReCIMP) the IUL cooperates with Faurecia's divisions Automotive Seating and Clean Mobility in a number of projects in the field of innovative metal forming processes. The superordinate objective of each project is to improve and deepen the basic knowledge of the processes and process chains under investigation. In addition, there is a focus on the identification and investigation of new scientific research directions in the field of manufacturing technology. The cooperation with other industrial companies and research institutions to build up a competence network is a welcome side effect. Moreover, the cooperation between the IUL and Faurecia supports the collaboration at the different sites of the company.

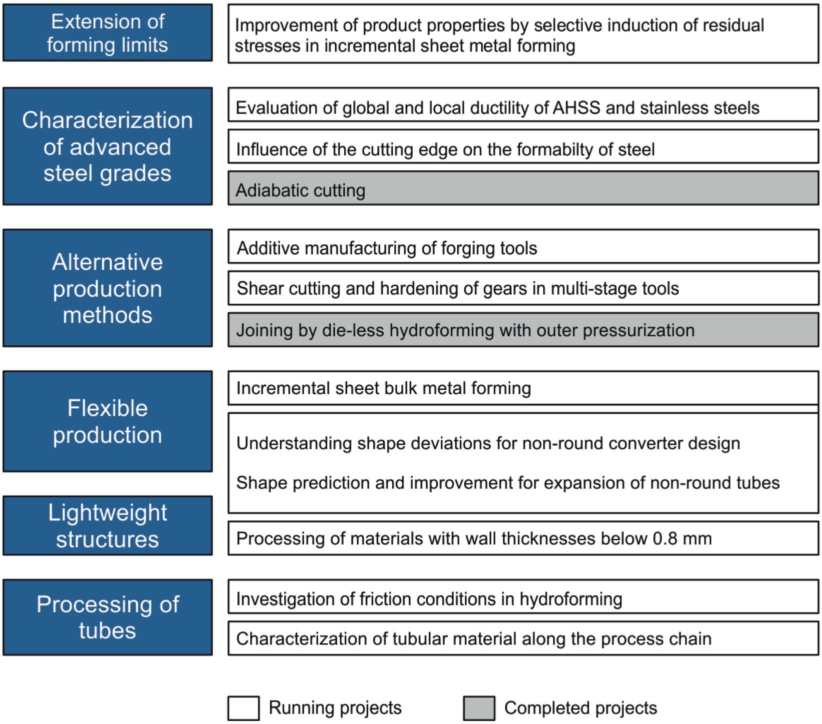
Structurally, the individual ReCIMP projects are assigned to the following six priority areas:

- Extension of forming limits
- Characterization of advanced steel grades
- Alternative production methods
- Flexible production
- Lightweight structures
- Processing of tubes

The project work is performed by scientists from the various IUL departments on a subject-specific basis. The Advisory Board of ReCIMP regularly discusses the progress of the individual projects as well as the overall strategy of the research center. The figure on the following page gives an overview of the projects carried out in 2019.

The researchers are supported by a large number of student assistants and students who prepare project or final theses in the projects. Since the establishment of the Research Center far more than 50 students have been involved in ReCIMP projects; for several current scientific employees of the IUL a thesis in ReCIMP was the first step towards a scientific career. In 2019 alone, eight project, bachelor, and master theses were written at the Research Center.

The cooperation is particularly effective when the research topics initially dealt with within the research center lead to fundamental questions and research fields for externally funded projects – as happened several times in the past years.



Research projects worked on in 2019

In the field of characterization of modern steel materials, the focus was on the evaluation of global and local ductility in 2019. Depending on the manufacturing process chain, one of the two properties is more important than the other. However, there are also cases in which a balanced relationship between global and local formability is of interest. The measurement of the parameters requires new approaches and was investigated in the project "Evaluation of global and local ductility of AHSS and stainless steels" on the basis of various steel grades for applications in the areas of "seating technology" and "exhaust tract". A short overview of the project results is given in chapter 2.4.7.

In the field of additive manufacturing it was investigated to what extent these manufacturing processes are suitable for the design of forging tools. Critical temperature peaks in the forging process can be reduced with near-contour tool cooling. The flexible processes of additive manufacturing offer a large degree of design freedom for such cooling concepts. In the context of a master thesis the effect of different cooling concepts on the part and tool temperature was numerically investigated.
A novel process chain for the production of geared components is investigated in the project "Shear cutting and hardening of gears in multi-stage tools", see chapter 2.4.8. It is investigated how the hardness of the workpiece to be produced can be purposefully influenced by means of an appropriate temperature control.

In addition to semi-finished sheet metal products, semi-finished tubes are used in particular for exhaust systems. For reasons of optimum use of the available space, non-round tubes are increasingly being used. The numerical simulation of forming processes for the processing of such tubes is the main focus of the project "Shape prediction and improvement for expansion of non-round tubes" (see chapter 2.2.2). Here, the focus is particularly on the investigation of the influence of different process parameters on the final geometry.

2.1.3 ReGAT – Research Group on Additive Technology

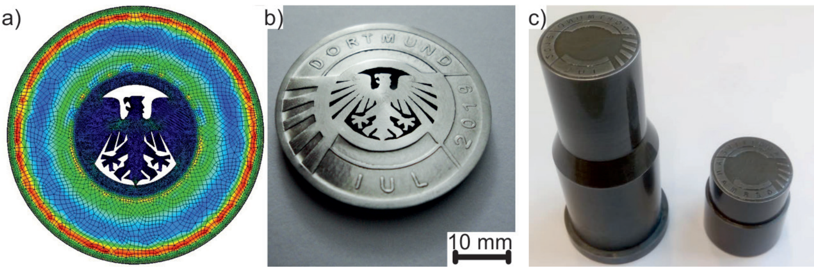
Contact Stephan Rosenthal, M. Sc.
Dr.-Ing. Dipl.-Wirt.-Ing. Ramona Hölker-Jäger (on parental leave)

The working group "Research Group on Additive Technology" (ReGAT) deals with the combination of forming technology and additive manufacturing. The working group pursues the goal of using the flexibility and design freedom of additive manufacturing processes in an advantageous way for the forming technology. Current research deals with the development of additively manufactured semi-finished products for further processing as well as the use of additive manufacturing processes for tool production or as part of the forming production chain.

The research group works with two additive manufacturing machines for metallic materials. On the one hand, a 5-axis milling machine with integrated laser-powder-deposition capabilities combining additive manufacturing and milling-post-processing. In this way, tools for forming operations can be produced in a single clamping device, thus saving time, cost, and material. It further offers the possibility of integrating functional elements. Stainless steel and tool steel can be processed additively or hybrid material concepts

Machines for additive manufacturing at the IUL can be produced by powder mixing. As part of a research project the milling machine was upgraded this year to include the option of incremental sheet metal forming. This was, it is possible to combine three manufacturing processes (forming, additive manufacturing, subtractive manufacturing) in one setup and to manufacture components for specific applications. The second additive manufacturing machine uses Selective Laser Melting (SLM). This process enables the production of highly functional metallic components in the powder bed with filigree geometry details. Current research in this field deals with the design of sandwich semi-finished products with core structures optimized for forming. By a subsequent forming operation of the semi-finished products the productivity of the process chain can be increased.

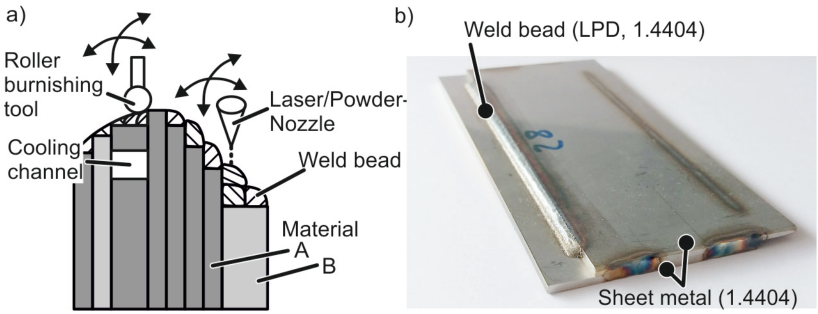
From March to June 2019, Prof. Carlos Manuel Alves da Silva, Assistance Professor at the “Instituto Superior Técnico” of the Technical University of Lisbon, continued his visit at the IUL, which had started in 2018. His research activities deal with the embossing of additively manufactured coin blanks for commemorative coins. To design the preform, he determined the material flow behavior in the embossing process by means of numerical simulations and characterized the additively manufactured material. To characterize different strain states in a compression test, he also investigates novel 3D-printed sample geometries.



Additively manufactured coin, a) numerical simulation, b) after coining operation, c) coining tool

As part of a further cooperation with Professor Christopher Saldana of the Georgia Tech University, additively manufactured semi-finished sandwich sheets are examined by means of computed tomography in order to be able to correctly predict the change of the geometry during a forming operation numerically. The results will be presented at the conference ICTP 2020 in Ohio.

A project to reduce the stair step effect of lamellar tools by means of additive manufacturing and surface burnishing was granted by the German Research Foundation (DFG, TE 508/82-1). This process offers the possibility to produce a large-volume body of a tool or a component of laminated sheet metal plates having different thicknesses and different materials to be built up quickly and inexpensively. The step effect occurring in this case is then filled by means of laser-powder-deposition and leveled by ball burnishing and/or milling. The process combination was patented in 2018.



Reduction of the “step effect” in the layer-laminate process using laser-powder-deposition and ball burnishing, a) process principle, b) preliminary test

Another project approved by the DFG deals with the functionalization of additively manufactured hot stamping tools by means of surface burnishing (TE 508/75-1). A new concept is developed where the tools are produced additively by laser-powder-deposition. Ball burnishing of the surface can change the material properties locally (strength, heat transfer coefficients). The idea is to specifically level the rough surface resulting from the additive manufacturing process and to adjust the contact conditions and influence the thermal transition conditions during the hot stamping process between sheet and die.

In May 2019, the European patent “Method and apparatus for the combined production of components by means of incremental sheet metal forming and additive processes in one clamping setup” (EP3197633B1) was granted. The technology is used in a project funded by the DFG to investigate a novel process combination of incremental sheet metal forming and laser-powder-deposition for the production of lightweight components with high functional integration (TE 508/68-1).

This year, several 3D printing workshops were organized at the IUL, supported by the KARL-KOLLE Foundation. Secondary school teachers were introduced to the technology of polymer-based 3D printing to prepare and promote the technology of additive manufacturing in education. This is intended to strengthen interest in MINT subjects even in early school education.

2.1.4 Research for Engineering Education – ELLI 2

ELLI 2 – Excellent Teaching and Learning in Engineering Science

Funding	BMBF/DLR
Project	01 PL 16082 C
Project director	Prof. Dr.-Ing. A. Erman Tekkaya
Contact	Joshua Grodotzki M. Sc. (Head of research group) Dipl.-Inf. Alessandro Selvaggio • Siddharth Upadhya M. Sc. Oleksandr Mogylenko M. Sc.

Engineering education is changing as quickly as the technology behind the transformation of manufacturing towards Industry 4.0. Higher education is supposed to be more digital, flexible, and individual than ever before. Accordingly, current engineering students should be better prepared for future working environments. Such a profound shift requires research for engineering education on a technological as well as methodological and didactical level.

Therefore, the cooperative project ELLI 2 between RWTH Aachen University, Ruhr-Universität Bochum (RUB), and TU Dortmund University, which is funded by the Federal Ministry of Education and Research as part of the Teaching Quality Pact since 2011, focuses on the research on teaching and learning in engineering sciences.

The project consists of four core areas:

- Remote labs and virtual learning environments
- Globalization
- Student Life Cycle
- Entrepreneurship

At TU Dortmund University, engineers from the IUL together with engineering education experts from the Center for Higher Education collaborate to resolve the questions regarding how future generations of engineers should be educated best. Within the core area of "Remote labs and virtual learning environments" two activities are mainly conducted by members of the IUL: (1) further development of the tele-operative testing cell and integration of new experiments as well as (2) the virtual laboratory for forming technology.

The ELLI team in front of the remote cell for material characterization

Thanks to a strong team effort, the software and hardware development for the virtual as well as remote laboratories was advanced extensively this year. The remote cell for material characterization was extended by a compression test, which is now available at the Zwick Z250 via remote control in addition to the already existing remote tensile test. Teachers as well as students can perform the new compression test in order to teach or learn about flow curves at higher strains or the effect of asymmetry under tensile and compressive loads. In addition, the way of accessing the equipment as well as its control were updated. This further improves the system's stability and enables the access from various mobile and non-mobile devices. The new system was used in full scale operation for the first time by the new MMT students who, before starting their master's program at TU Dortmund University, performed a tensile test via remote control from their home countries as part of an international collaboration task.

At this year's International Conference on Remote Engineering und Virtual Instrumentation (REV) in Bangaluru, India, the team showed the most recent developments. Along with the project presentations the conference attendees could test the technologies themselves in a demo session. Alessandro Selvaggio was awarded the Best Paper Award for his article on the development of the remote compression test. At the conference for digital higher education in NRW (e.Learn NRW) the remote laboratories were offered to the attendees in an interactive format. On top of that, the newly founded Community Working Group on Remote Laboratories was promoted. Using the current laboratories, the educators were encouraged to join the working group and invest in this topic.

Apart from the contributions to these conferences, an article was submitted to the book Hochschullehre & Industrie 4.0, published at the wbv-Verlag. It deals with the challenges of changing technologies and how higher education needs to adapt to these changes. The article draws a visionary outlook on engineering education in the world of tomorrow and connects this to the current developments in the ELLI project. The reader is encouraged to rethink current trends in engineering education and open research questions are presented.

One of the project's goals is – besides improving education at the institute and promote its digitization – to use its resources to support other institutes and chairs in and outside the department of mechanical engineering to actively invest in their future education. For this purpose, a new workshop series was initiated by the ELLI members from the IUL and the center for higher education, in which scientific assistants from other institutions can learn about good digital engineering education based on the experiences from the ELLI project. The IUL introduces the topics of flipped classroom concepts, the use of mobile apps in lectures, and the incorporation of remote laboratories in online lectures. The ELLI team not only supervises the IUL's internal lectures and exercises, but also helps other research projects, like the TRR 188, to generate high quality educational content based on their research findings.

Another important mission of the project is to engage young scholars and school teachers to use modern, digital technologies as part of their teaching/ learning experience. For this purpose, a workshop on 3D printing, specifically designed for school teachers, was held for the second time at the IUL. The teachers came from very different backgrounds like arts, math, and biology, yet the workshop was able to provide the necessary skills to all of them to incorporate the 3D printing technology in their respective field at school. The KARL-KOLLE Foundation donated a 3D printer starter kit to each participant after completing the workshop. By this, the teachers could work with the new technology right away and inspire their students to get involved not only in engineering, but also in other fields of STEM. The starter kit is well suited for a low-level entry to work and modify a seemingly complex machine as well as to learn about designing and coding. Aside from this workshop, the ELLI team contributed to all other TU Dortmund University initiatives, like MinTU, Girls'Day, and more, where scholars can actively participate in special university lectures or workshop and become interested in studying STEM subjects.

2.2 Department of Applied Mechanics in Forming Technologies

Head Dr.-Ing. Till Clausmeyer

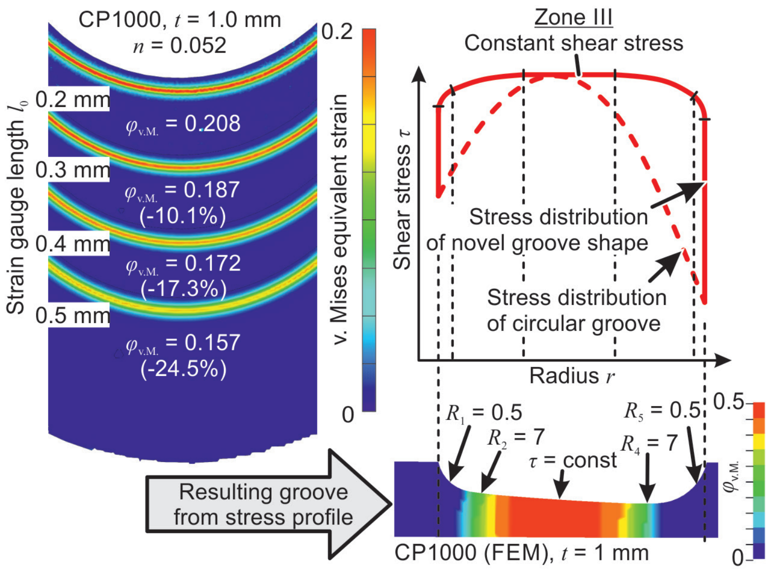
The team members of the department of Applied Mechanics in Forming Technologies develop new tests to determine the mechanical properties of materials for forming. This data is used for new material models and the identification of material parameters. The consideration of the microstructure and its effect on the component properties play an important role in this context. The team members advance the development of processes such as high speed blanking with this knowledge. Thick blanks made of high-strength material are sheared in one single step by means of this process. To benefit from further advantages of the process, such as the high cutting edge accuracy, the institute purchased a new machine (ADIACLIP 1000). The team members welcomed several international scientists in 2019, Prof. Frederic Barlat from the Republic of Korea, Dr. Christopher Saldana from the USA, Prof. Kaan Inal from Canada, and Prof. Yanshan Lou from China. Dr. Clausmeyer organized the first visit of a delegation of Bao Steel as the starting event of a research collaboration.

Members of the department in front of the newly acquired ADIACLIP 1000 high speed blanking machine

2.2.1 Novel In-Plane Torsion Specimen for the Characterization of Damage and Hardening

Funding	German Research Foundation (DFG)
Project	TE 508/65-1
Contact	Heinrich Traphöner M. Sc.

Shear tests as well as the in-plane torsion test show a concentration of strain in a narrow range of the specimen. The use of digital image correlation (DIC) measures strain in a discrete area of the sample. Local strain differences in the discrete areas can not be detected, which can result in a deviation of up to 25% in the measured strains, depending on the measurement setting and material properties. The in-plane torsion test is suitable to estimate the expected error analytically by the localization due to the full analytical description of the stress and strain state. This shows in particular the large influence of work hardening on the measurement error. A new stress-adapted groove shape makes it possible to generate a constant strain along a defined radial area, with the localization having no influence on the measured results. In the first experimental tests with the new groove the measurement error could be reduced to less than 2% deviation, independent of the material.

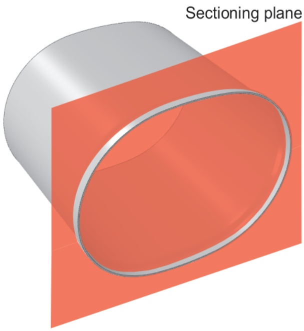


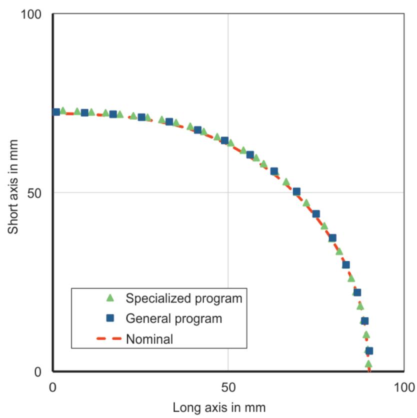
Influence of the strain gauge length on the measured strain for CP1000 and new stress-adapted groove contour to avoid strain localization

2.2.2 Shape Prediction and Improvement for Expansion of Non-Round Tubes

Funding ReCIMP
Contact Dr.-Ing. Till Clausmeyer

The increasing variety of model variants of automobile manufacturers leads to a large number of different exhaust systems. This is associated with a customization of the component geometries resulting in more complex cross sections. To meet the strict form tolerances, an efficient process design is required so that new geometries can be fabricated without time-consuming tuning loops. Finite element models are used for numerical simulations of oval, non-round tube sections. For an efficient process design the comparison of a general forming simulation program (GP) and a specialized simulation program (SP) shows clear differences. It shows a good agreement of the calculated geometries with the nominal contour, but the calculation times differ significantly (see figure). In addition, the influence of different flow curves, which are determined by tensile tests, on the fabricated components at different stages of the process as well as of different sheet thicknesses on the final geometry is examined.





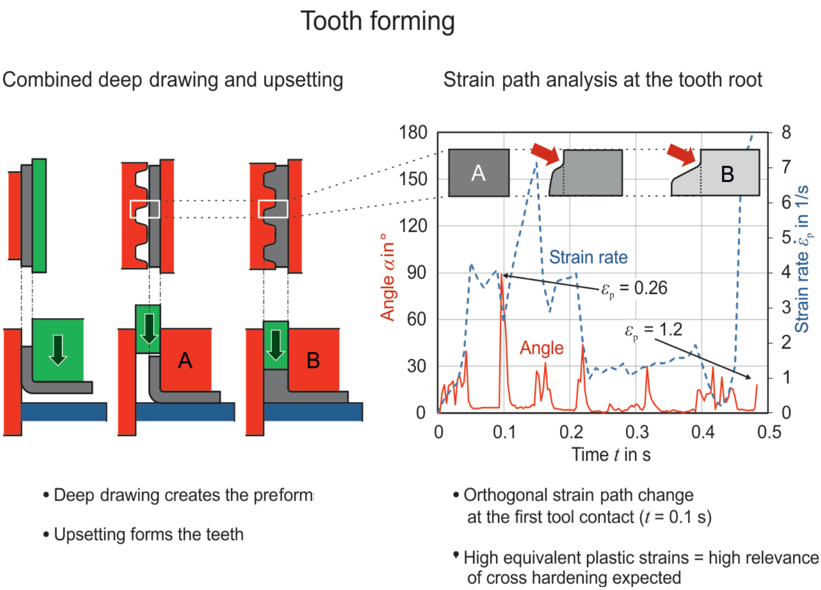
	Long axis in mm	Short axis in mm	Deviation in %	Calculation time in h
General program	90.31	72.59	0.22	13.9
Spec. program	89.91	72.82	0.84	0.05
Nominal	90.1	72.1	-	-

Prediction of the geometry of the expanded edge: Comparison of simulations with SP und GP

2.2.3 Analysis of Strain Path-Dependent Damage and Microstructure Development for the Numerical Design of Sheet-Bulk Metal Forming Processes

Funding	German Research Foundation (DFG)
Project	CRC/TR73 • Subproject C4
Contact	Florian Gutknecht M. Sc.

Sheet metal forming involves the application of bulk forming techniques to sheet metal and sheet metal components. By this means, a variety of functional elements can be integrated and efficiently produced. This novel set of techniques usually combines high non-linear strain paths with high local strains. Metallic materials often have different plastic properties (e.g. yield stress, formability) after a change in the strain path. In particular, the phenomenon of cross hardening – a sudden increase in yield stress after an orthogonal strain path change – is investigated.
Numerical investigations have shown that during the lateral forming of teeth after a deep drawing process an orthogonal strain path change occurs in the region of the tooth root. Together with the Institute of Materials Science at Leibniz Universität Hannover the influence of strain path changes on microstructural damage is investigated.

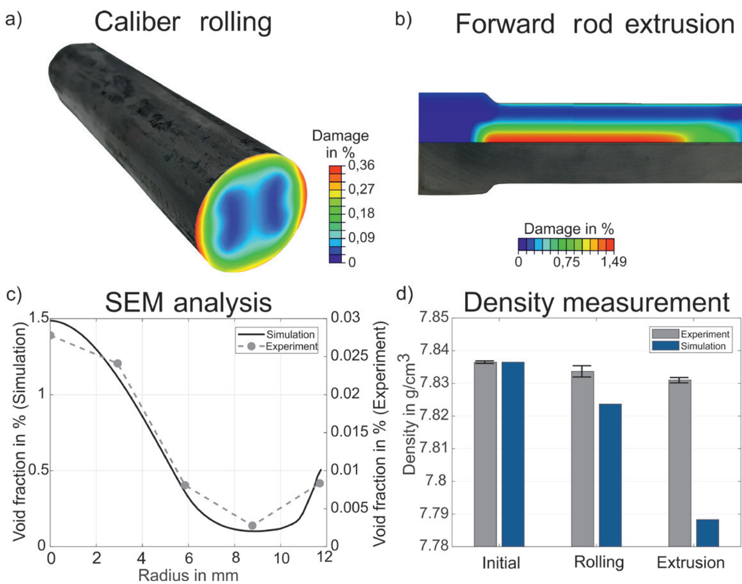


Tooth forming: Schematic process (left), strain path analysis at tooth root (right), ε_p indicates current plastic strain

2.2.4 Model Integration for Process Simulation

Funding	German Research Foundation (DFG)
Project	CRC/TRR 188 • Subproject S01
Contact	Alexander Schowtjak M. Sc.

Numerical simulations are used to optimally design forming processes in the SFB/TRR 188. So far, processes are investigated in terms of damage only for single forming operations. Although semi-finished products or multi-stage forming processes have an influence on the damage evolution, they are generally not considered in the literature. The process chain of a caliber rolling process with 4 stages and subsequent forward rod extrusion is investigated in this collaborative project with the Institute of Mechanics. A Lemaitre model is used for the prediction of the damage evolution with FE simulations. Field outputs like stresses and damage have been analyzed throughout the process chain. While the highest damage evolution in caliber rolling appears on the outside, the maximum damage in the extrusion process is located in the center. This leads to the conclusion that caliber rolling barely influences the damage evolution during subsequent forward rod extrusion. The simulated data was validated experimentally by means of SEM analyses and density measurements.

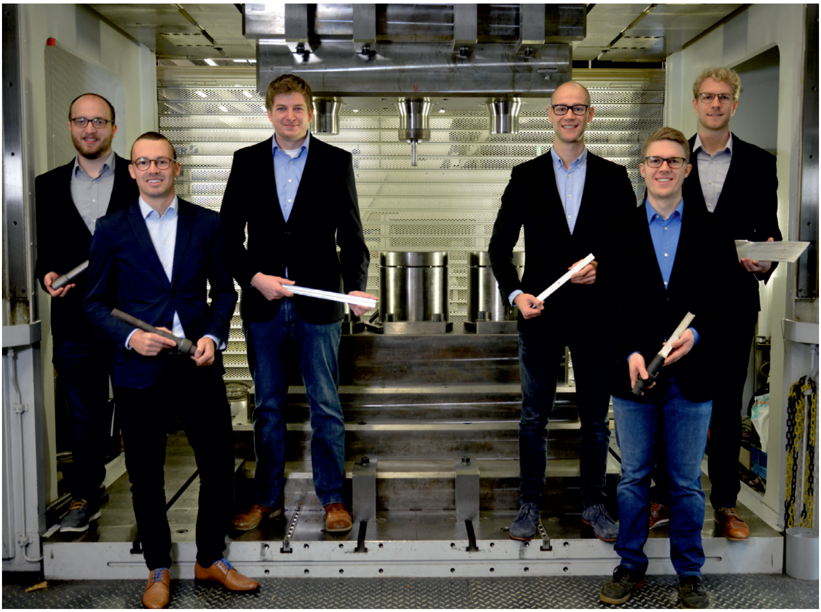


Damage evolution in a caliber rolling (a) and forward rod extrusion process (b), validation in terms of SEM analysis (c) and density measurements (d)

2.3 Department of Bulk Metal Forming

Head Oliver Hering M. Sc.

The focus of the department of bulk metal forming is on the investigation of the processes hot extrusion and cold forging. Fundamental issues as well as innovative processes and process variants are investigated. In the field of fundamental research, the influence of the Bauschinger effect occurring during load reversal as well as the influence of forming-induced damage on the performance of cold forged components are investigated. The occurrence of unwanted longitudinal press seams is one focus of research in the field of extrusion. The process development aims at the implementation of lightweight-oriented process designs. Here, a major aspect is the investigation of processes for the production of hybrid components. By using the processes composite cold forging and combined deep drawing and cold forging, lightweight and load-adapted components can be realized. Composite hot extrusion enables the combination of different materials and the embedding of functional structures such as shape memory elements.

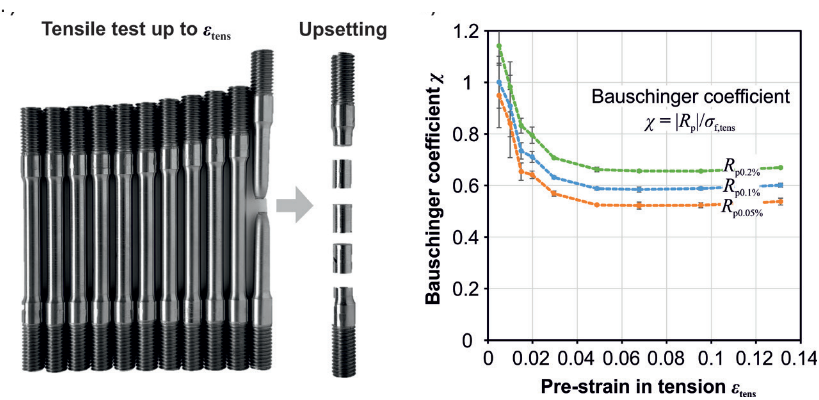


Members of the department of bulk metal forming

2.3.1 Influence of the Multiaxial Bauschinger Effect in Cold Forging

Funding	German Research Foundation (DFG)
Project	TE 508/77-1
Contact	Felix Kolpak M. Sc.

The goal of this project is the investigation of the influence of load reversal effects on the properties of cold forged components. Previously, it was shown that cold extrusion causes a significant direction dependence of work hardening in a finished part. This direction dependence is never considered in the component design, leading to flawed predictions of the part's properties as well as the expected process forces in cold forging operations with multiple stages. To reach these goals, experimental characterization methods are currently derived and compared to quantify the Bauschinger effect as well as additional load reversal effects such as permanent softening and work hardening stagnation. The evolution of those effects with the pre-strain is of special interest for the investigations (see Figure a). First results suggest that the Bauschinger effect saturates with the pre-strain (see Figure b), however, all other load reversal effects become more pronounced. Further investigations include the influence of hydrostatic pressure as well as the influence of temperature and strain rate.

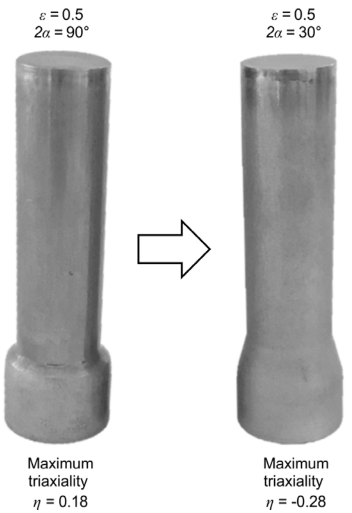


a) Characterization of load reversal effects, b) Saturation of the Bauschinger effect

2.3.2 Influencing the Evolution of Damage in Cold Extrusion

Funding	German Research Foundation (DFG)
Project	CRC/TRR 188 • Subproject A02
Contact	Oliver Hering M. Sc.

In addition to the influence of residual stresses and strain hardening, damage in the form of pores affects the product performance of cold forged components. The effect of the geometrical and procedural parameters such as extrusion strain, die angle, and friction on the load path was investigated numerically. The load path-dependent damage was determined in produced components by microscopy investigations. Subsequently, it was possible to determine the isolated influence of damage on the product performance of the components by means of measurements of the Young's modulus, the impact energy, and the number of cycles to failure in fatigue tests. A change in the die angle from $2\alpha = 90°$ to $2\alpha = 30°$, for example, leads to a significant change of component performance (see figure). In the further course of the project, possible load path changes in the production of multi-stepped shafts as well as the use of counter pressure will be investigated and the consequences for the performance of the components will be shown.



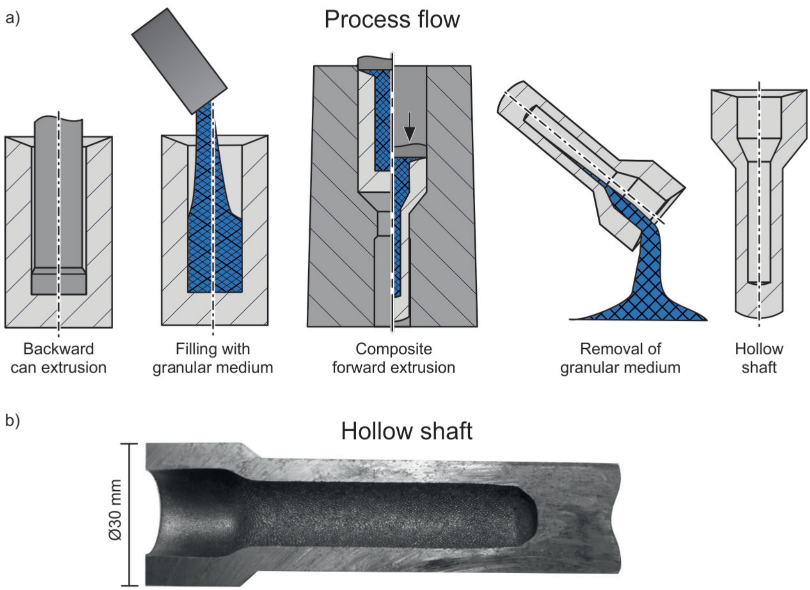
	Percentage change
Void volume fraction	- 74 %
Cycles to failure	+ 25 %
Impact energy	+ 79 %
Young's modulus	+ 9 %

Influence of a change in die angle on damage and product performance

2.3.3 Composite Cold Forging of Cold Forged Semi-Finished Parts

Funding	German Research Foundation (DFG)
Project	TE 508/54-2
Contact	Robin Gitschel M. Sc.

Up to now, composite shafts were successfully manufactured from an aluminum-steel composite. To this end, cylindrical aluminum cores were inserted into backward cup-extruded steel parts. This hybrid semi-finished part was then processed to a composite shaft by means of forward cold forging. For the purpose of further weight reduction, composite shafts with magnesium or polymeric cores are investigated. The manufactured parts are heat-treated to set certain microscopic and mechanical properties. Thus, strategies are developed that allow for heat treatment of the steel sleeve without affecting the softer core in a negative way. The lightweight design potential can be further increased by utilizing lost cores. The core material is removed after forward cold forging, such that a hollow shaft is obtained (see figure). Experiments and numerical investigations show that especially granular media like zirconia beads or quartz sand are well-suited core materials for the manufacture of hollow shafts.

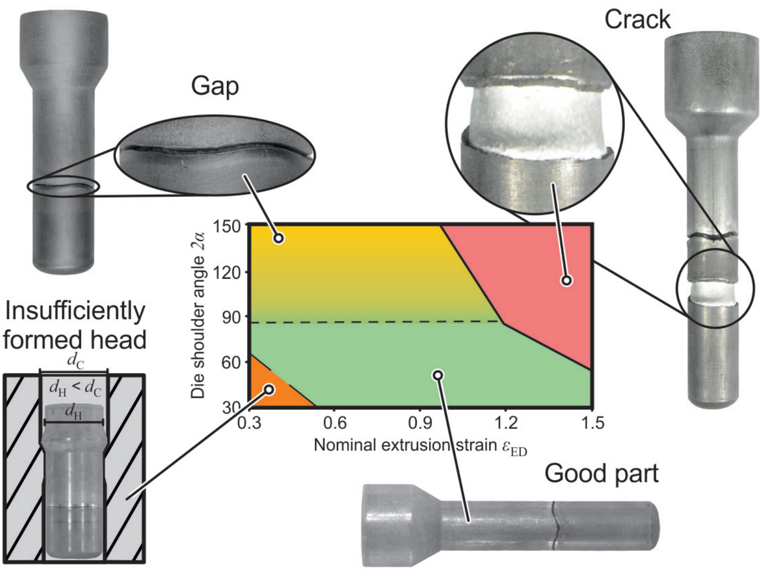


Process flow and produced hollow shaft

2.3.4 Process Combination of Combined Deep Drawing and Cold Forging

Funding	German Research Foundation (DFG)
Project	TE 508/61-1
Contact	Johannes Gebhard M. Sc.
Status	Completed

In order to adjust the local mechanical properties of a component, the combination of different materials is a common approach. Draw forging couples deep drawing and cold forging in one process. It combines a sheet blank (e.g. steel) with a cylindrical core (e.g. aluminum), with the sheet material defining the surface properties of the component. In the course of the processing an analytical description of the process mechanics was first developed, which was then validated by numerical and experimental investigations. The three process errors – crack of the blank, insufficient forming of the component head, and gap formation on the component shaft – were determined and analyzed. Based on the results, a process window was determined (see figure) and strategies suitable for extending the process limits were derived. These include, among other strategies, the application of a counter pressure and the patent pending process variant of "expanding-draw-forging", which makes it possible to cover each shaft step with a different material.

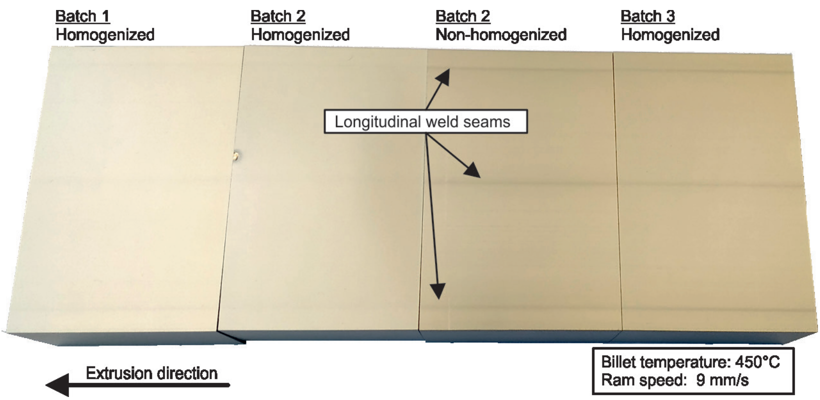


Process window: core = 3.3206, blank = 1.4301, drawing ratio = 1.8, sheet thickness = 1.5 mm

2.3.5 Prevention of Longitudinal Weld Streak Defects on Anodized Aluminum Profiles

Funding	AiF/Stifterverband Metalle
Project	18756 N
Contact	Johannes Gebhard M. Sc.
Status	Completed

A frequently occurring process error of hot extruded aluminum profiles are longitudinal weld seam defects, which only appear after anodization and can lead to rejection. In cooperation with the companies being part of the project's advisory board - Hueck, Gerhardi Alutechnik, HMT Höfer Metall Technik, and Wilke Werkzeugbau - the influencing factors on the occurrence of weld seam defects during the process chain billet casting, homogenization, extrusion, and anodization were analyzed. Using light and electron microscopy, the microstructure was examined by the Institute for Applied Materials of the Karlsruhe Institute of Technology. The experimental investigations show that the billet quality, in particular homogenization and the exact alloy composition, have a large impact on the visibility of the weld streaks, whereas the extrusion parameters billet temperature and ram speed only have small influence on the streaking. The figure shows the anodized profile surface for different cast batches and states of homogenization.

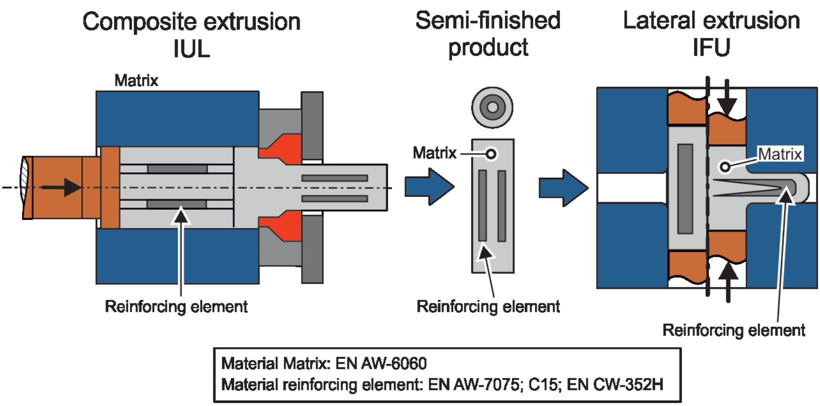


Comparison of the influences of pouring batch and homogenization of the pressing block on the weld streak

2.3.6 Production of Flange-Shaped Components by Cold Forging of Composite Hot Extruded Semi-Finished Products

Funding	German Research Foundation (DFG)
Project	TE 508/72-1
Contact	Patrick Kotzyba M. Sc.

In cooperation with the Institute for Metal Forming Technology of the University of Stuttgart (IFU), the production of flange-shaped components by composite bar extrusion of semi-finished products is being investigated. The IUL analyzes how semi-finished composite products made of aluminum with internal tubular reinforcing elements can be produced by composite bar extrusion. At the IFU this step is followed by further processing, i.e. flange upsetting or lateral extrusion (see figure). Compared to components made of homogeneous material, these hybrid components exhibit increased strength, stiffness, and functionality. At the IUL the possibilities for the cohesive connection of the composite billets are investigated by adapting the underlying extrusion process parameters, such as extrusion ratio and diameter as well as wall thickness of the tubular reinforcing element, during bar extrusion. The materials used for the reinforcing elements are high-strength aluminum alloys, low-alloyed steel, and copper.

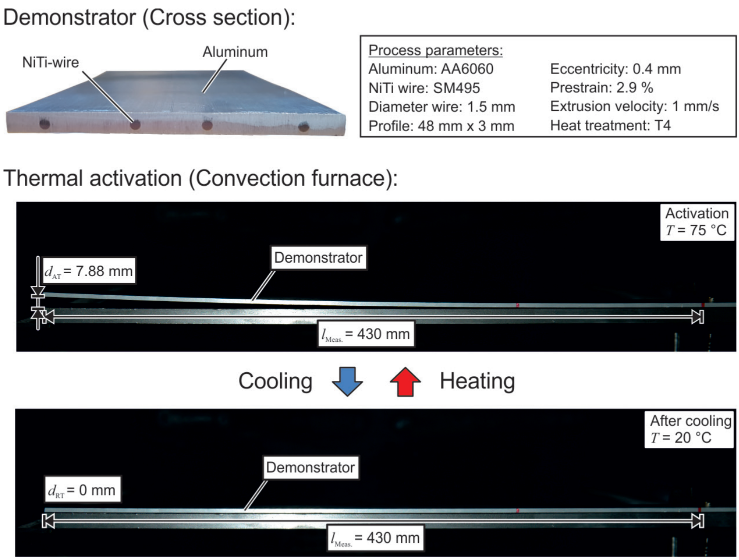


Process sequence for manufacturing flange-shaped components with reinforcing elements

2.3.7 Manufacture by Forming and Characterization of Actuator Profiles Based on Shape-Memory-Alloys

Funding	German Research Foundation (DFG)
Project	TE 508/45-2
Contact	Oliver Hering M. Sc.
Status	Completed

In cooperation with the IAM-WK of the Karlsruhe Institute of Technology (KIT) the manufacturing of shape memory alloy metal matrix composites by means of composite extrusion was investigated. Experimental, analytical, and numerical methods were developed and tested for the specific design of the profiles. Due to the embedding of shape memory wires (SM495), the mechanical properties of the extruded profiles (tensile strength, ductility, energy absorption capacity) can be significantly increased in dependence of the testing temperature. In addition, a repeatedly usable bending function can be generated in the profile when it is thermally activated (see figure). The bending function requires an eccentric positioning of the wires and subsequent stretching of the profile. The effects are based on the targeted induction of compressive stresses, which are generated by the embedded shape memory wires and can be transferred due to the solid bonding of both composite partners.

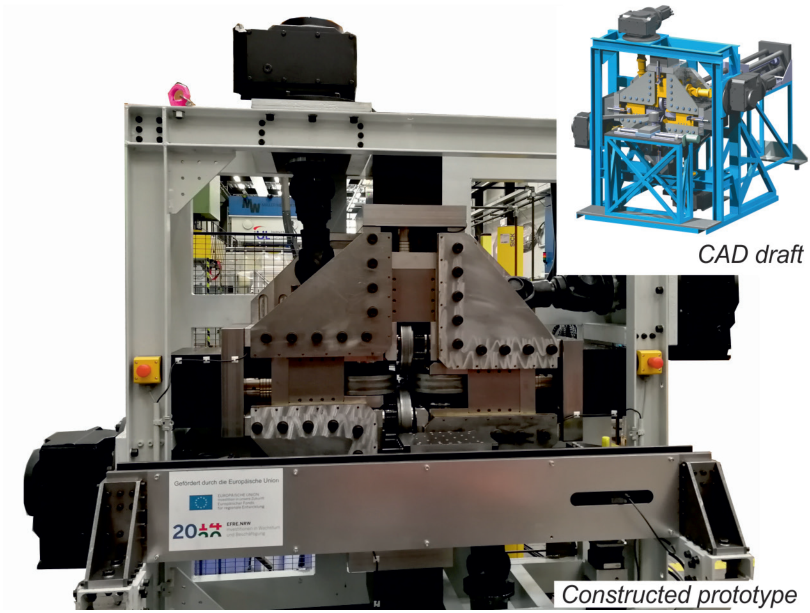


Repeatedly usable bending function of composite profile

2.4 Department of Profile and Sheet Metal Forming

Head Dr.-Ing. Christian Löbbe

The focus of the department is on new processes for forming of profiles, tubes, and sheets as well as on the fundamentals of established forming processes. In addition, process optimization is realized and industrial research services are provided.
In 2019, incremental tube forming was qualified for aircraft tube components, which allows a high design freedom due to the integrated cross rolling step. Furthermore, the basics of tube expansion and press hardening with granular media were obtained, which are now available on the basis of process limits for the process variants. For profile bending, a press brake process has been optimized that eliminates wrinkling. Current work focuses on controlling the damage evolution for better a performance of bent components, profile bending under compressive stresses and at elevated temperatures for higher dimensional accuracy, testing the ductility of high-strength steels, and thermo-mechanical forming for improved forming and product properties.

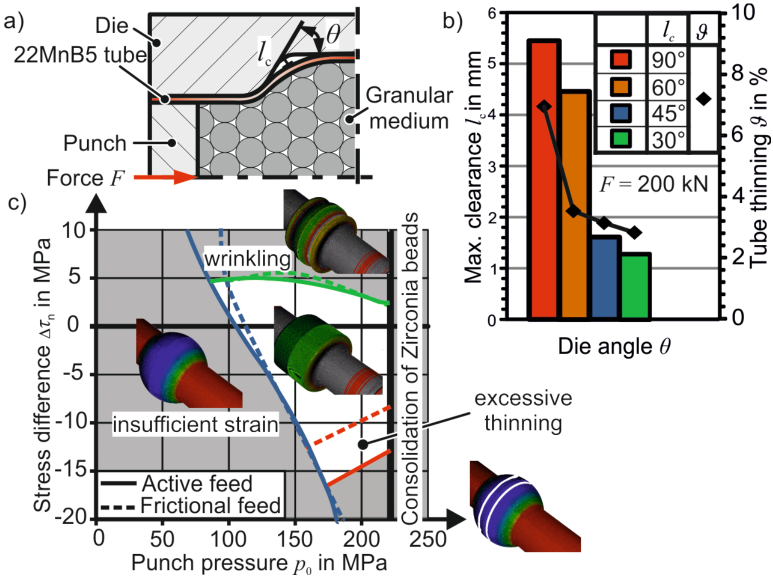


The picture shows the new self-built prototype for profile bending with compressive stress superposition

2.4.1 Granular Media-Based Tube Press Hardening

Funding	German Research Foundation (DFG)
Project	TE 508/52-1 • SP 714/12-1 • BO 4174/2-1
Contact	Eike Hoffmann M. Sc. • Sigrid Hess M. Sc.
Status	Completed

The process combination of press hardening and tube hydroforming enables the production of high-strength hollow profiles exhibiting high stiffness. The application of solid granular particles as alternative forming medium was investigated. The frictional nature of granular medium leads to inhomogeneous force and pressure distributions so that its behavior during forming differs from conventional fluids or gases. It was shown that the friction coefficients between die/granular medium and tube/die control an axial feed mechanism of the tube. A higher friction of the granular medium favors a better flow behavior of the tube. Unfortunately, higher friction in the medium also reduces the transferred axial pressure. Therefore, a tool with active axial feed was developed and the die geometry was adapted (see Figure b) so that the process window could be extended significantly in the area of tube thinning (see Figure c). The project was carried out in collaboration with the Institute of Materials Physics in Space of the German Aerospace Center (DLR) in Cologne.

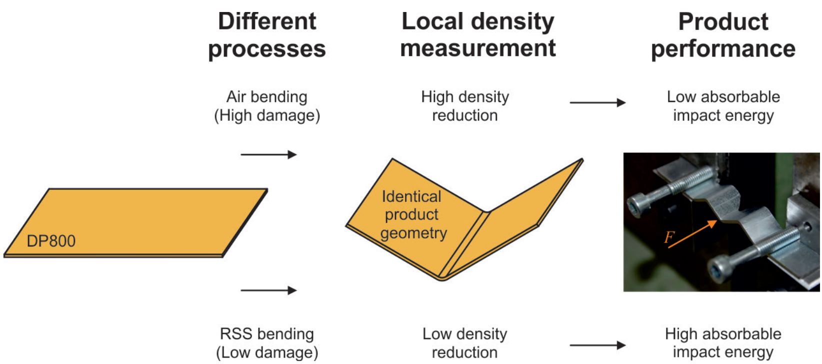


a) Die geometry, b) Influence of die geometry on tube thinning for a flat punch and Zirconia beads, c) Process window

2.4.2 Damage in Sheet Metal Bending of Lightweight Profiles

Funding	German Research Foundation (DFG)
Project	CRC/TRR188 • Subproject A05
Contact	Rickmer Meya M. Sc.

Bent parts made of high-strength steels are often produced by conventional bending processes such as air or die bending. In these processes a control of the stress state at the outer fiber without geometry changes is not possible by varying conventional process parameters. The stress state during bending can therefore only be influenced by externally applied compressive stresses. For this purpose, bending with radial stress superposition (RSS bending) has been developed. This process is capable of superposing compressive stresses in the forming zone. These lead to a lower damage evolution in the component during bending. The reduced damage can be detected by local density measurements and scanning electron microscopy. The reduced damage leads, for example, to increased absorbable impact energies. To test the impact energy of bent components, a modified sample geometry with multiple bending zones has been used (see figure). The influence of strain hardening on the absorbable impact energy can be separated using identical component geometries.

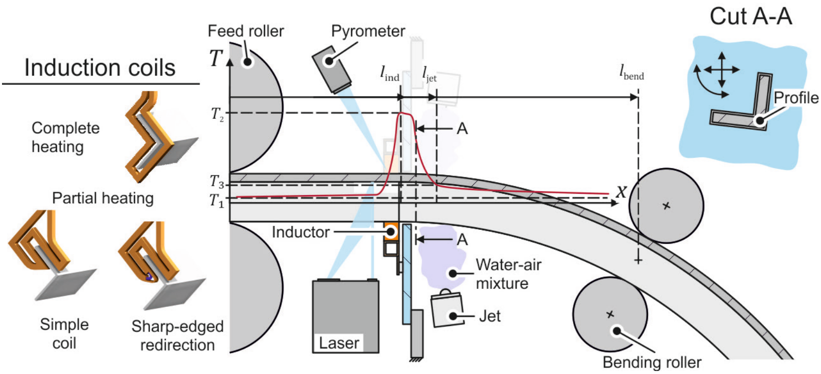


Influence of different processes on the damage evolution and on the performance of bent products

2.4.3 Kinematic Profile Bending with Partial Cross-Sectional Heating

Funding	German Research Foundation (DFG)
Project	TE 508/74-1
Contact	Eike Hoffmann M. Sc.

In this project, the suitability of tailoring the mechanical properties and the reduction of geometrical deviations through partially heat-treating profiles in bending processes is examined. Therefore, preferably asymmetric profiles are heated by induction and subsequently quenched with an air-water mixture after the forming process, leading to partial hardening in the heat-treated area. Deviations from the perfect geometry occur especially during bending operations of asymmetric profiles. The position of the shear center is relocated through thermal softening of one profile side, which reduces the twisting of the profile. The softening should additionally prevent material failure in the form of buckling and wrinkling. Currently, the investigation focuses on the behavior of L-profiles in this process. Present results show that if the load acts on the heat-treated area, wrinkling occurs more frequently compared to loading of the non heat-treated area.

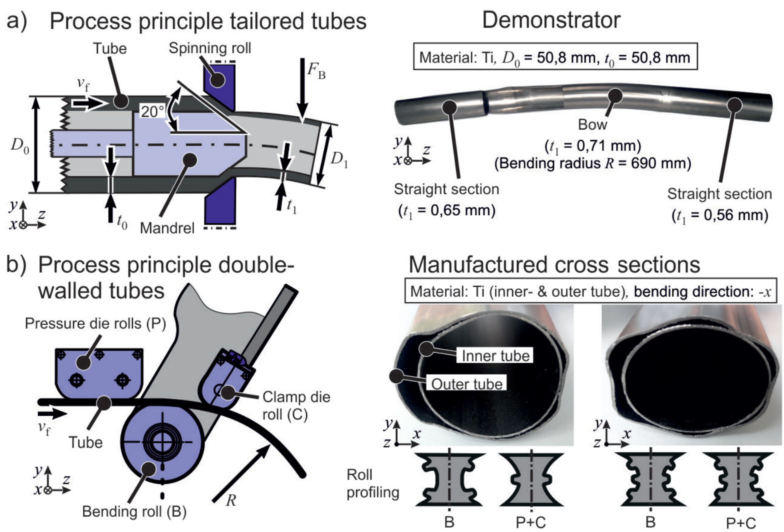


Reduced geometrical deviations in bending of asymmetric profiles, if only one side is heat-treated.

2.4.4 Freeform Bending of Aviation-Relevant Tubular Parts

Funding	BMWi/DLR
Project	20W1514B
Contact	Rickmer Meya M. Sc.
Status	Completed

The aim of the research project was the development and qualification of manufacturing technologies for the production of bent tubes with minimum setup work for use in the aviation industry. There was a cooperation with PFW Aerospace GmbH. In addition to the fundamental analysis of freeform bent titanium and titanium alloy tubes using the incremental tube forming (ITF) process, the project also produced special tube components with flexible freeform bending techniques.
On the one hand, bent tailored tubes were produced (see Figure a). For this purpose, a mandrel was used in the ITF process and the wall thickness – and, if required, the outside diameter – was adapted during the forming process. With this manufacturing method costly joining of individual tube segments with different wall thicknesses by welding and the associated testing can be avoided. On the other hand, curved double-walled tubes were created using a new process combination of roll-based freeform bending with integrated forming of the outer pipe (see Figure b). For this process the rolls are profiled.

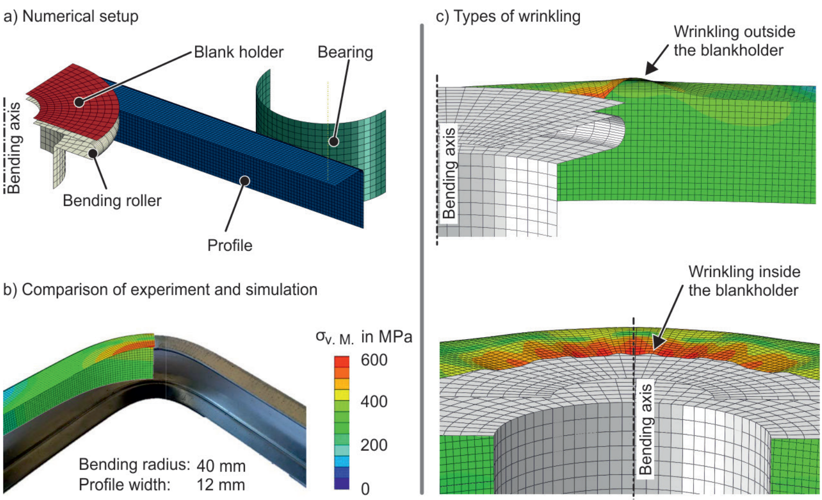


a) Tailored tubes: Principle and demonstrator, b) Double-walled tubes: Principle and cross sections

2.4.5 Method for Producing Bent Profiles with Small Bending Radii and Closed Contours

Funding	BMWi/ZIM-ZF
Project	ZF4101104US6
Contact	Johannes Gebhard M. Sc.
Status	Completed

Bending of CNC-stamped sheets into profiles is a flexible and economical possibility for the production of frame structures. So far, the geometry that can be produced by forming technology was limited to large radii. In co-operation with the company FLORA GmbH & Co. KG different methods for the production of small radii were examined numerically, analytically, and experimentally. For an economic production of small quantities a process understanding must be developed to avoid failed attempts and rejects. The achievable bending ratio is particularly limited by wrinkling and could be significantly reduced by controlled dipping of the profile ground, support of the profile walls, and adjustment of the length of the lever arm. The picture shows a) the setup of the experiment, b) the comparison of simulation and experiment, and c) the types of wrinkles occurring here. In order to enable an individual production, a modular tool concept was developed which allows the bending of different profile geometries, sheet thicknesses, and bending radii.

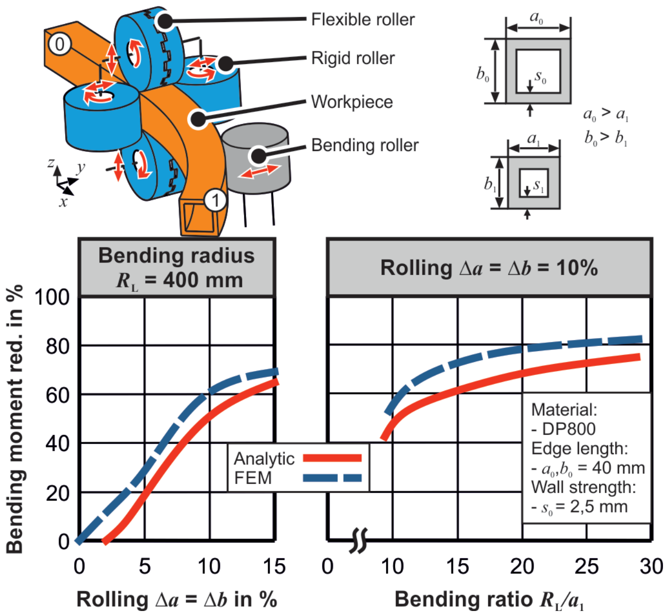


a) Experimental setup, b) Comparison of simulation and experiment, c) Occurring wrinkles

2.4.6 Development of a Profile Bending Process with Compressive-Stress-Superposition by Rolling

Funding	LeitmarktAgentur.NRW
Project	EFRE-0400139
Contact	Juri Martschin M. Sc.
Status	Completed

When bending profiles made of high-strength steel, bending stresses of more than 1000 MPa may occur. High bending stresses cause process limitations such as the formation of wrinkles on the inner arc of the bent profile or the deformation of the profile cross section. As part of the NRW patent validation, a combined rolling and bending process is being developed for high-strength steels, which reduces the bending stresses by means of compressive stress superposition. To quantify the stress reduction, the resulting bending moment was determined by numerical simulations (see figure). In addition, an analytical model was developed for a simplified process design. A comparison of the applied bending moments taking into account the change in the cross section shows that a bending moment reduction of up to 80% is achieved. At present, the machine is under construction to test the process principle.

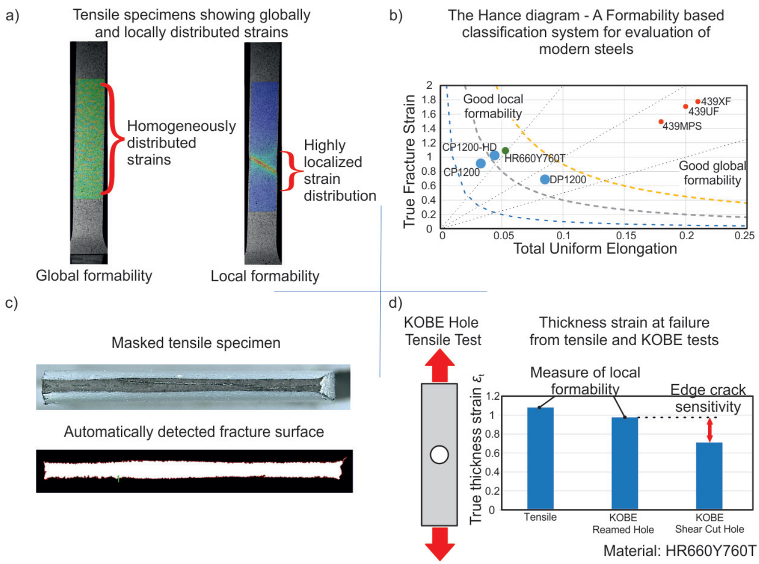


Bending moment reduction during bending with compressive stress superposition by rolling at const. bending radius R_L and const. rolling $\Delta a = \Delta b$

2.4.7 Evaluation of Global and Local Ductility of AHSS and Stainless Steels

Funding ReCIMP
Contact Dr.-Ing. Christian Löbbe

The ability of a metal to withstand uniformly distributed strains is termed as global formability and, conversely, the ability to resist fracture under highly localized strains defines its local formability (see Figure a). Depending on the manufacturing process, better performance under either of these conditions is desired. Plotting the global formability (Total Uniform Elongation TUE) versus the local formability (True Fracture Strain TFS) allows the systematic evaluation of different modern steel grades (see Figure b). Conventionally, the fracture surface area required for TFS calculation is measured manually. To overcome inaccuracies due to irregular boundaries and excessive necking, the specimens are masked and an automatic area detection approach is developed (see Figure c). In addition to the local formability, the shearing-induced edge crack sensitivity must also be characterized. The KOBE hole tensile test is determined as a viable alternative to the error-prone hole expansion test as a simple method to characterize both local formability and crack sensitivity (see Figure d).

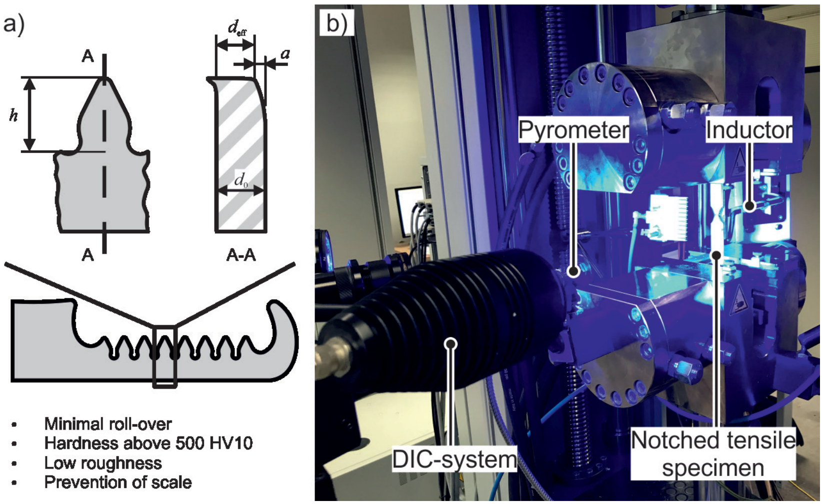


a) Global/localized straining, b) Hance diagram, c) Automatic fracture area measurement, d) KOBE test

2.4.8 Shear Cutting and Hardening of Gears in Multi-Stage Tools

Funding ReCIMP
Contact Dr.-Ing. Christian Löbbe

In automotive engineering there is a conflict between the lightweight design and the maintenance of crash safety. One possible solution is the application of press-hardened steels. As part of the ReCIMP project, the manufacturing of gearing parts for passenger car seats by hot stamping in a multi-stage progressive die is examined as an example. In the process, high demands on the product (see Figure a) with a given component complexity should be realized at low costs and for large quantities. By varying the active elements in the heat-assisted progressive die the influence of different pre-cuts is taken into account. An adaptation of the inductive heating integrated in the tool as well as the clock rate and the servo curve facilitate an influence on the quenching process. In addition, the interaction of the thermo-mechanical process parameters is investigated by tensile tests (see Figure b) and modeled by means of numerical simulation.

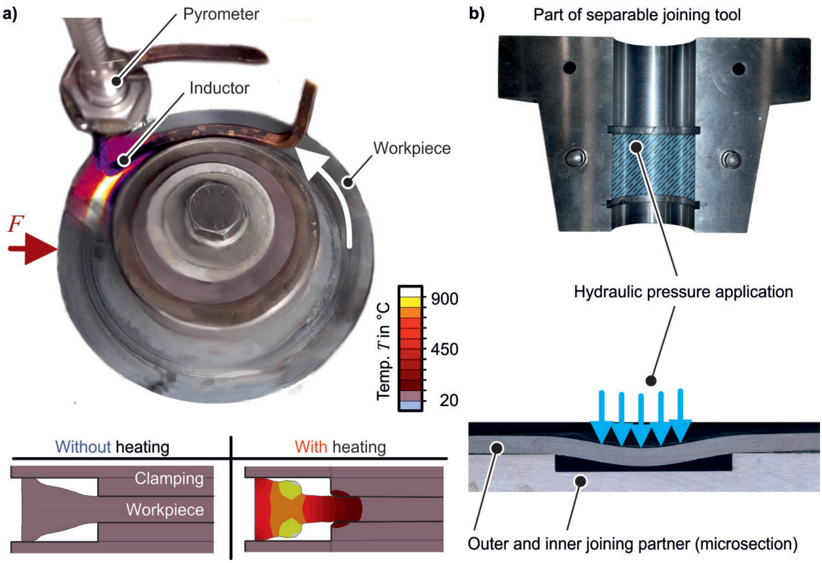


a) Requirements for the shear-cut components, b) Tensile test for material characterization

2.5 Department of Non-Conventional Processes

Head Marlon Hahn M. Sc.

The research activities of the department of non-conventional processes focus on technologies which offer distinct advantages such as extended process limits. These processes are either very new or so complex in nature that they have not yet been applied widely in industry. Current topics are forming with high strain rates, joining by forming, forming of hybrid or novel semi-finished products, and incremental forming. In the latter case, the application of local heating strategies in sheet bulk-metal forming is a current exemplary research topic (see Figure a). This way, high-strength materials can be formed. Other beneficial consequences are lower process forces and, thus, lower tool wear. A current joining topic is, for example, the application of hydroforming from the outside of profile-like parts (see Figure b). Within all fields of activities both numerical and analytical methods as well as up-to-date measuring techniques are used and permanently enhanced for an in-depth process analysis. The team currently consists of nine researchers.

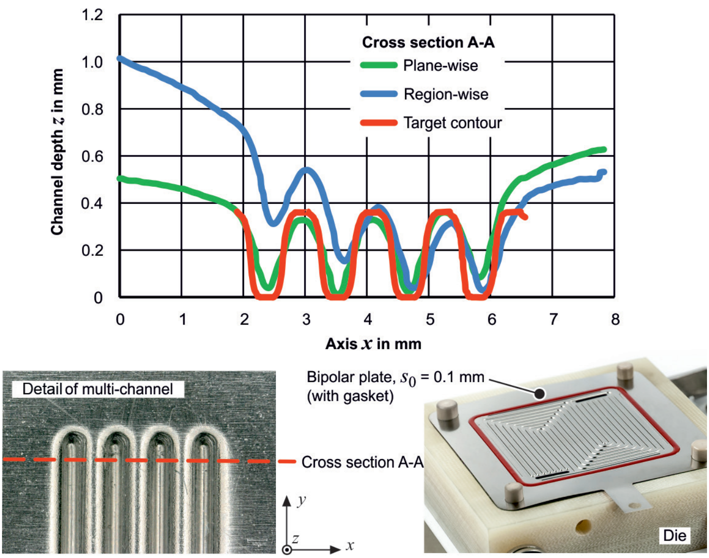


Exemplary non-conventional processes: a) Heating for edge-thickening, b) Tube joining by outer pressure

2.5.1 Development of an Incremental Micro-forming Process for the Small Batch Production of Metallic Bipolar Plates

Funding	AiF/FOSTA
Project	14 EWN/P1247
Contact	Lennart Tebaay M. Sc.
Status	Completed

So far, the development of metallic bipolar plates for fuel cells was done by using either deep drawing or hydroforming, which are both cost-intensive conventional processes. Incremental micro-forming was introduced as a flexible alternative for the manufacture of the flow fields. Stainless steel foils (initial thickness s_0 = 0.1 mm) were used as semi-finished products. With regard to minimizing the friction between the filigree tool and the foil, three tool concepts were developed and tested: A rigid one, a rotating one, and an oscillating one. In order to increase the contour accuracy of the flow fields, different tool path strategies were investigated (see figure). After the forming operation a process-specific distortion remains due to the springback phenomenon. This distortion could almost be completely eliminated with the help of a heat treatment. A successful test trial for a single-cell fuel cell was conducted in cooperation with the project partner “The hydrogen and fuel cell center” (ZBT GmbH, Duisburg).

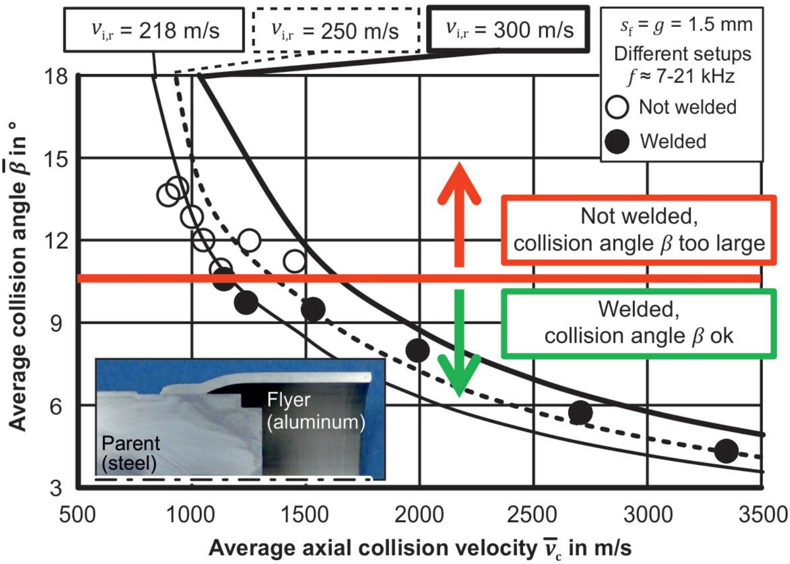


Geometry comparison with respect to different tool path strategies in micro-forming

2.5.2 Magnetic Pulse Welding: Targeted Manipulation of Weld Seam Formation

Funding	German Research Foundation (DFG)
Project	TE 508/39-3 (SPP 1640 • Subproject A1)
Contact	Dr.-Ing. Dipl.-Wirt.-Ing. Jörn Lueg-Althoff
Status	Completed

With the third project stage of the DFG Priority Program 1640 ("Joining by Plastic Deformation"), the basic investigations on magnetic pulse welding of tubular joining partners were completed. In cooperation with the Institute of Manufacturing Science and Engineering of TU Dresden novel measuring systems were developed, allowing to investigate the influence of the impact energy, the positioning and contouring of the joining partners as well as the discharge frequency on the collision conditions and the welding mechanism (see figure). The influence of the wall thickness s_f of the accelerated outer joining partner ("flyer") was also investigated. It was shown that at the same impact velocities $v_{i,r}$ larger wall thicknesses result in higher kinetic energy, but the axial forming behavior is more decisive for the formation of the weld seam. Larger flyer wall thicknesses result in smaller average collision angles β. This leads to higher temperatures in the joining gap which favors the formation of the weld seam.

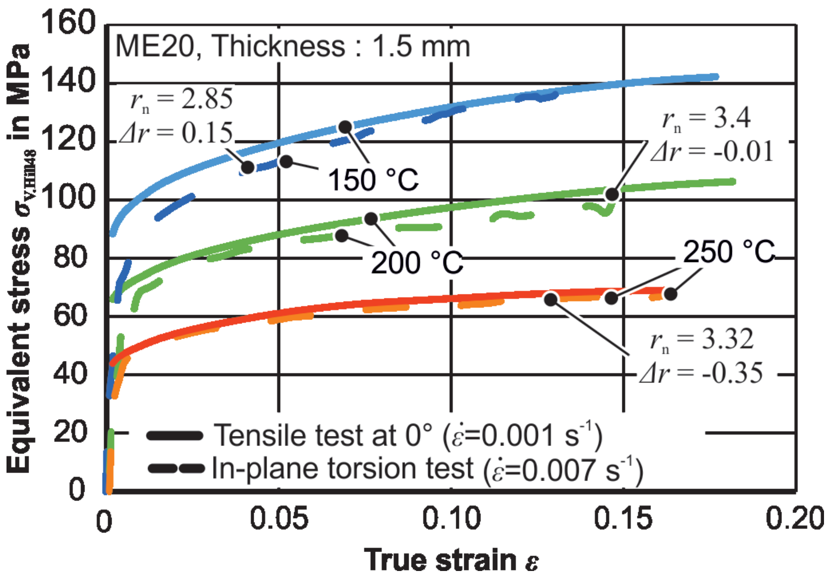


Welding window in the dimensions $\overline{v}_c$ and $\overline{\beta}$

2.5.3 Development of Hybrid Plastic/Magnesium Composite Parts for Ultra-Light-Construction Applications (KuMag)

Funding	LeitmarktAgentur.NRW
Project	EFRE-0800113
Contact	Hamed Dardaei Joghan M. Sc.
Status	Completed

In cooperation with IKV Aachen, JUBO, KODA and TWI, the combined process for the production of hybrid plastic/magnesium composites was developed to provide an efficient lightweight solution. The project was divided into several steps: The production of magnesium sheets by extrusion, development of a coating and adhesion promoters, characterization of material behavior during forming and back injection, modeling of the combined process, cutting of the material, and, finally, production of the combined tool and a hybrid component. In this context, a detailed characterization of the magnesium material for a tailored sheet and for sheets with constant thickness was carried out. Two new tools were developed for the in-plane torsion test at elevated temperatures. The material behavior under cyclic loading was investigated for different temperatures using this in-plane torsion test. In cooperation with the project partners a combined tool for the production of the hybrid plastic/magnesium material was realized.

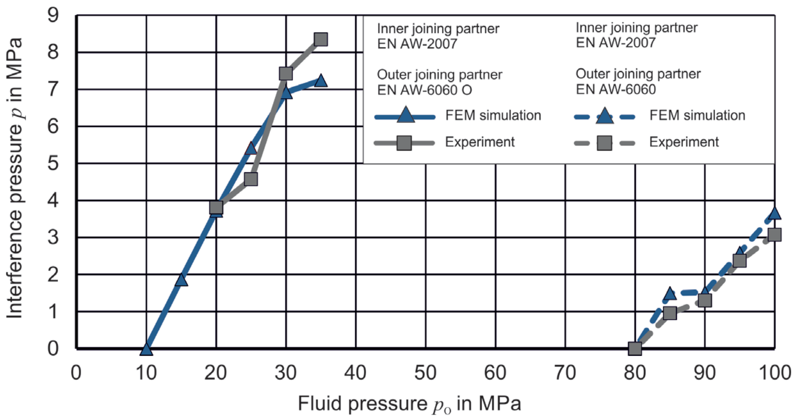


Comparison between tensile test and warm in-plane torsion test at different temperatures

2.5.4 Die-less Hydroforming by Outer Pressurization

Funding	German Research Foundation (DFG)
Project	TE 508/66-1
Contact	Florian Weber M. Sc.
Status	Completed

The aim of this project was the determination of the process limits of force- and form-fit tube-to-tube joints, established by outer pressurization through a fluid. One aspect of the project was the numerical investigation of the influence of geometrical parameters, like the joining gap between the two joining partners, on the forming process. In addition, numerical and experimental studies regarding the influence of the ratio of the initial yield stress and the Young's modulus of the outer joining partner, in relation to that of the inner one, were of interest in terms of analyzing the resulting force-fit formation. It can be deduced from the figure that a small value of the mentioned ratio results in a higher interference pressure p, with even less hydraulic pressure being needed. In the course of investigating form-fit joints, one focus was the analysis of the influence of the unloaded area of the outer joining partner, resulting from the developed sealing concept, on the groove filling. No significant influence could be found.

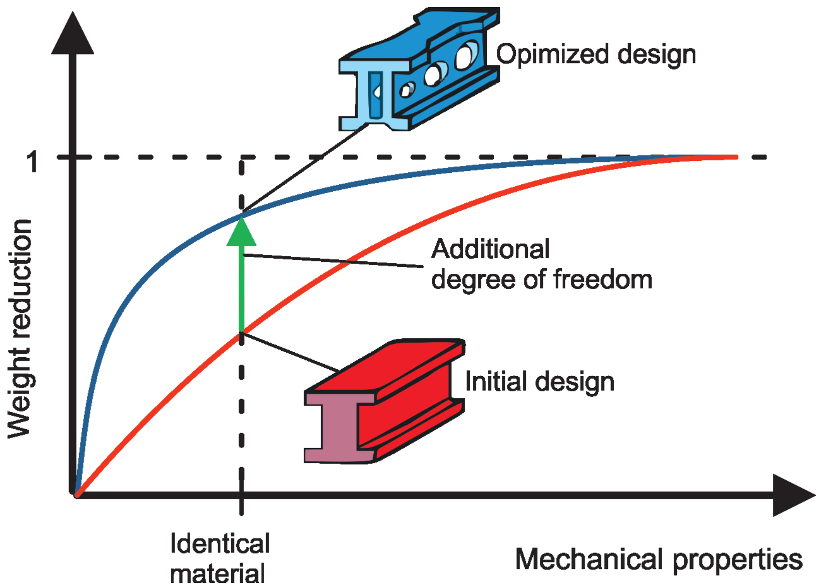


Influence of the joining partner material on the interference pressure

2.5.5 Forming Technologies for Metallic and Hybrid Lightweight Structures for the Use in Electromobility

Funding BMBF/PTKA • Grant Platform FOREL 2
Project 02P16Z011
Contact Fabian Schmitz M. Sc.

In this coordination project in collaboration with TU Dresden, TU Bergakademie Freiberg, Paderborn University, and the Technical University of Munich, topics dealing with future mobility are addressed, in particular with a focus on numerical prediction accuracy and lightweight design. The aim of the project is to identify current research fields for electromobility and to provide possible solutions for problems with suitable milestones. The evaluated time period covers 10 years in which the subgoals can be achieved. To encourage this, plenary surveys are carried out at conferences and interviews with experts from various functional areas, from which interdisciplinary guidelines are developed. One milestone already reached is the development of a new characteristic value concept (see figure) that enables a more objective evaluation of lightweight designs and, thus, questions the often prevailing paradigm of "lightweight construction simply meaning being lighter than the previous product version".

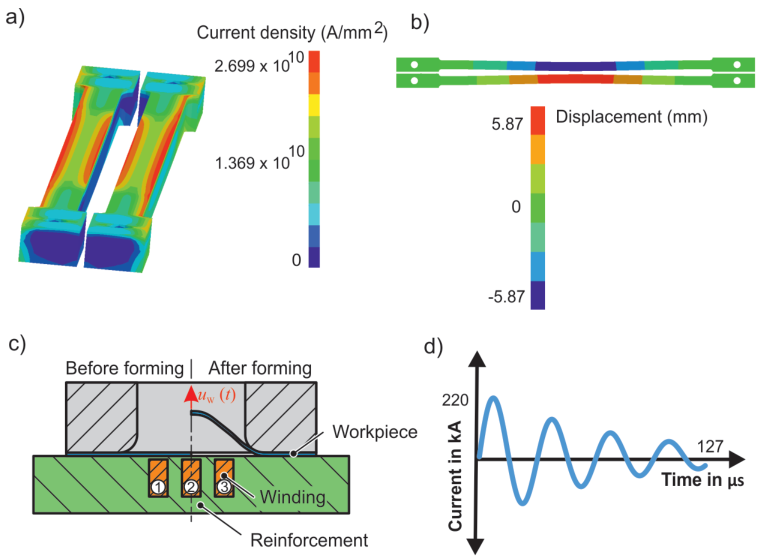


New concept for an objective evaluation of lightweight design

2.5.6 Optimized Working Coil Windings for Electromagnetic Forming Employing Additive Manufacturing Techniques

Funding	German Research Foundation (DFG)
Project	TE 508/51-2
Contact	Siddhant Prakash Goyal M. Sc.
Status	Completed

In collaboration with the Institute of Machine Tools and Factory Management of TU Berlin the second funding period of the project is conducted with the objective of developing scan-strategies for additive manufacturing of multi-turn coils and a related process design for electromagnetic forming. The current focus of research at the IUL is the study of the proximity effect in the coils for the copper alloy CuCr1Zr (see Figure a, b). First, a numerical model is created in LS-DYNA for the material CuCr1Zr considering the temperature and strain rate-dependent behavior. The experiments are then carried out with varying coil geometries, coil proximities, boundary conditions, and discharge energies (see Figure c). For the same input current (see Figure d), the thermomechanical-electromagnetic simulations are performed and coil and workpiece displacement results compared and validated, respectively. This enables the establishment of a correlation between energy discharged, coil proximities, and coil deformation.

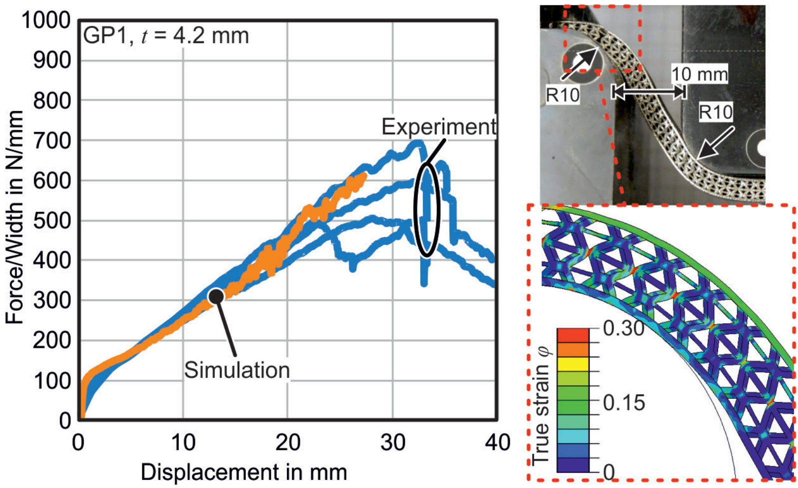


a) Proximity effect, b) Relative displacement, c) Schematic of the experiment, d) Current discharge

2.5.7 Forming of Additively Manufactured Sandwich Sheets with Optimized Core Structures

Funding	German Research Foundation (DFG)
Project	TE 508/63-1
Contact	Stephan Rosenthal M. Sc.
Status	Completed

In cooperation with the Institute for Product Engineering of the University of Duisburg-Essen composite sandwich panels with core structures optimized for forming are developed. The sandwich panels are manufactured in a monolithic or hybrid construction approach. As a result, two metallic materials can be combined within the process. The semi-finished sandwich sheets are formed into the final geometry in a subsequent forming operation. Additive manufacturing allows integrating functions such as cooling channels or sensors. Current investigations deal with the forming behavior of the sandwich sheets and core structures in the U-bending test with blankholder. In particular, one focus is to provide an approach to numerically predict the forming behavior of such complex and filigree core structures properly. The additive production of such structures can lead to a deviation from the nominal geometry, which has an effect on the results of the numerical simulations and, thus, requires a correction.

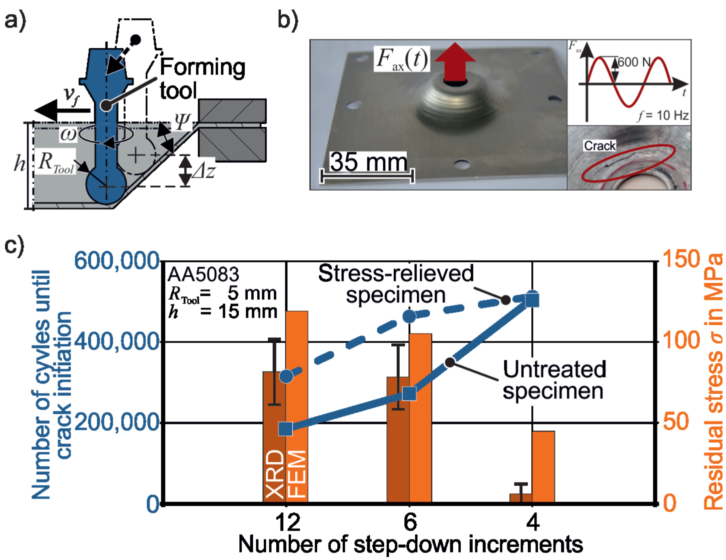


Comparison of numerical simulation and experiment of a U-bending process with blankholders

2.5.8 Improvement of Product Properties by Selective Induction of Residual Stresses in Incremental Sheet Metal Forming

Funding German Research Foundation (DFG)
Project TE 508/67-2 (SPP 2013)
Contact Fabian Maaß M. Sc.

The objective of the project SPP 2013 is the deliberate use of forming-induced residual stresses in metal components. In collaboration with the Department of Metallic Materials (TU Berlin), the Single Point Incremental Forming process (SPIF, see Figure a) is analyzed regarding the acting forming mechanisms and the residual stress state. In the first funding period it was shown that the residual stress of the component can be adjusted by the choice of process parameters. In the second funding period the achievable improvement of the product properties of components with process-induced residual stresses is evaluated. The resulting fatigue strength of components is analyzed as a key parameter (see Figures b and c) in this context. Process enhancements are developed to enable amplified residual stresses or even a reversed residual stress state. A fundamental understanding of the influence of disturbances on the residual stress development is also investigated. Finally, the incremental forming of products with application-specific residual stress states will be possible through process design.

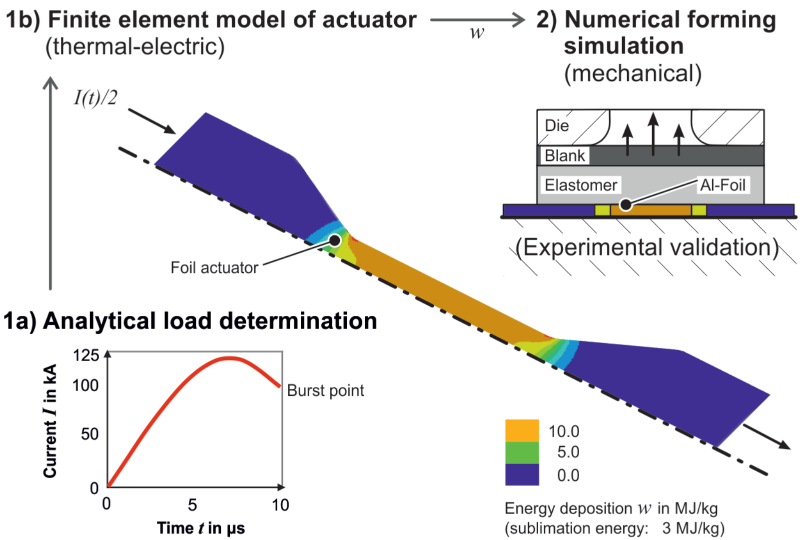


a) SPIF process, b) Fatigue test, c) Adjusting component properties by process parameters

2.5.9 Forming by Locally Varying Vaporizing Actuators

Funding	German Research Foundation (DFG)
Project	TE 508/69-1
Contact	Marlon Hahn M. Sc.

A thin aluminum foil can be vaporized by an intense current generated through a rapid capacitor bank discharge (called vaporizing actuator). The resultant pressure is used to impulsively form a sheet metal blank. For the development of a predictive process model a two-step approach with a one-way coupling is chosen to represent the multi-physical nature of the process. The first step consists of the energy deposition until the so-called burst point (example shown in figure). The required transient input load current is supplied by a validated analytical modeling scheme which incorporates the process parameters. The initial forming pressure is then deduced from the specific energy distribution. This way, the actual forming dynamics can be numerically modeled from the burst point on in the second modeling step. Meshless methods are considered for this due to the severe volume changes during the actuator expansion. Regarding the sheet metal workpiece, experimentally determined flow curves with strain rates up to $2{\cdot}10^4\ s^{-1}$ are taken into account.

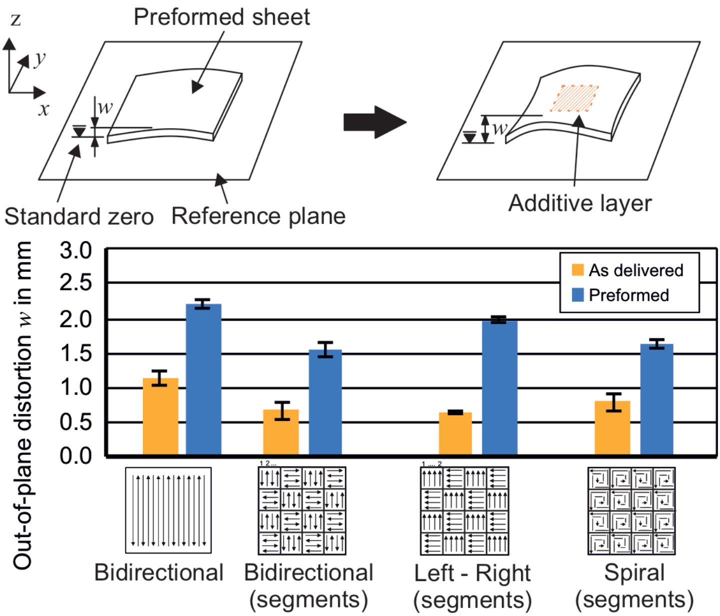


Modeling steps for sheet metal forming by means of vaporizing foil actuators

2.5.10 Process Combination of Incremental Sheet Forming and Laser Powder Deposition for Lightweight Manufacturing

Funding German Research Foundation (DFG)
Project TE 508/68-1
Contact Lennart M. Tebaay M. Sc.

The aim of this project is the analysis of the process combination of incremental sheet forming (ISF) and laser metal deposition (LMD) with respect to its fundamentals and interactions. The investigation focuses on the effects of ISF having an influence on the application of functional additive elements. The incrementally formed sheet metal is used as the substrate for the following LMD process. Depending on the part geometry and the ISF process parameters, different surface topologies and sheet thicknesses result. As a consequence, it is necessary to adjust the additive process parameters to obtain an optimized bonding of the functional element. Apart from this, the surface of the sheet can be post-treated by ISF, e.g. by rolling, to generate a smooth surface topology. Nevertheless, there is a thermal distortion of the substrate because of the energy input of the laser. With a segmentation of the cladding surface and an adaption of the laser movement it is possible to reduce this distortion (see figure).

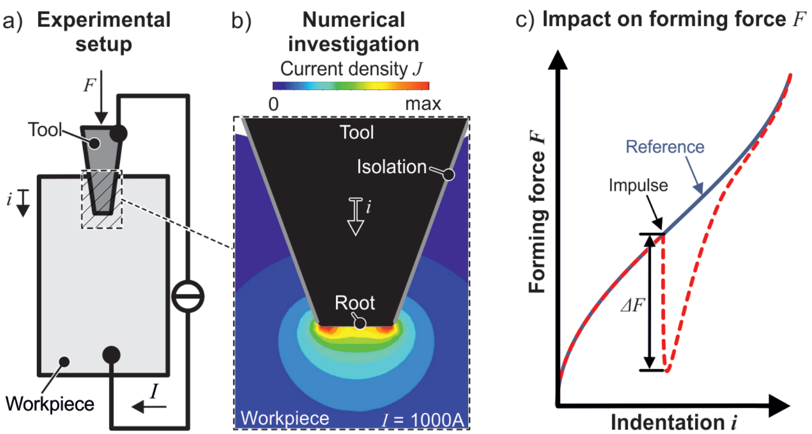


Segmentation of the additive layer and variation of the laser path movement to reduce thermal distortion

2.5.11 Fundamental Research and Process Development for the Manufacturing of Load-Optimized Parts by Incremental Forming of Metal Sheets – Sheet-Bulk Metal Forming (SBMF)

Funding	German Research Foundation (DFG)
Project	SFB/TR 73 • Subproject A4
Contact	Sebastian Wernicke M. Sc.

In subproject A4 of the Transregio 73 the main objective is the manufacturing of geometrically complex components from sheet metals with integrated functional elements by forming. With the incremental procedure the sheet is processed by a flexible arrangement of localized forming operations. This enables a local adjustment of the wall thickness with no need for further machining processes. Current investigations focus on increasing the tool life by a reduction of the mechanical tool load. Therefore, the tool is flooded during the forming operation by an electrical current pulse $I(t)$ (see Figure a). By an electrical isolation of the tooth flank the current density J is concentrated in the forming zone which is located at the root (see Figure b). Depending on the electrical charge Q, a temporary reduction of the forming force F (see Figure c) up to 55% can be realized. The adapted distribution of the current density J reduces the Joule heating of the formed gear so that strain hardening inside the formed gear is not significantly influenced.

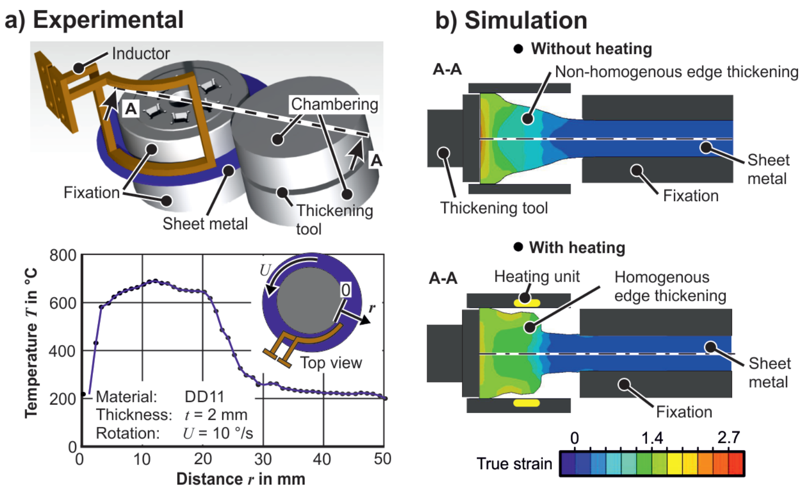


a) Schematic setup, b) Current density distribution, c) Force drop during electrically-assisted forming of gears

2.5.12 Incremental Sheet-Bulk Metal Forming by Application of Thermally-controlled Grading Mechanisms

Funding	German Research Foundation (DFG)
Project	SFB/TR 73 • Subproject T04
Contact	Stefan Gallus M. Sc.

One problem in incremental sheet-bulk metal forming is that during edge-thickening (see Figure a) only the outer blank edge is heavily thickened, while the thickness drops radially towards the middle of the blank. By thermal grading of the blank the yield stress can be reduced locally. This aims at the control of the axial material flow towards the homogenization of the thickened blank height. This could already be shown in numerical simulations (see Figure b). The DFG transfer project is carried out in cooperation with the industrial partners Winkelmann Powertrain Components GmbH + Co. KG, thyssenkrupp Hohenlimburg GmbH, Faurecia Autositze GmbH, and voestalpine High Performance Metals Deutschland GmbH. In the course of first investigations, heating strategies for setting the temperature profile are evaluated. Corresponding results show a thermal gradient of 20 K/mm for inductive heating (see Figure a). Furthermore, tests for analyzing the change in sheet thickness and the determination of product properties (e.g. hardness distribution) are planned.



a) Experimental setup and temperature profile, b) Simulation of edge-thickening

2.6 Patents

2.6.1 Granted Patents

Title	Device and method for two- or three-dimensional bending of profiles by means of rolling
Application number	EP 3 320 994 B1
Patent holder	TU Dortmund University
Status	Granted May 1, 2019
Inventors	R. Meya • A. E. Tekkaya

Title	Device and method for bending profiles or bar material, in particular asymmetric and open profiles or bar material
Application number	EP 3 320 993 B1
Patent holder	TU Dortmund University
Status	Granted July 3, 2019
Inventors	C. Löbbe • G. Grzancic • A. E. Tekkaya

Title	Method and device for increasing the thickness of the edge of a sheet metal body
Application number	EP 3 323 527 B1
Patent holder	TU Dortmund University
Status	Granted August 21, 2019
Inventors	S. Wernicke • S. Gies • A. E. Tekkaya

Title	Method and device for the combined production of components by means of incremental sheet forming and additive methods in one clamping setup
Application number	EP 3 197 633 B1
Patent holder	TU Dortmund University
Status	Granted May 1, 2019
Inventors	R. Hölker-Jäger • N. Ben Khalifa • A. E. Tekkaya

2.6.2 Published Patents

Title	Device and method for thickening the edge of the workpiece

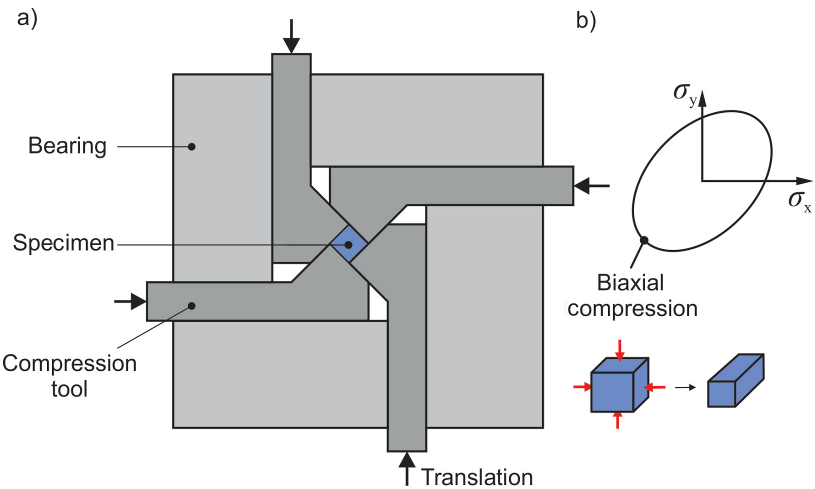
Application number	EP 3 498 394 A1
Patent holder	TU Dortmund University
Status	Filed June 19, 2019
Inventors	S. Wernicke • P. Sieczkarek • S. Gies • A. E. Tekkaya

2.6.3 Filed Patents

Device and Method for the Conduction of Compression Tests on Specimens to Characterize Materials as well as Corresponding Test Specimens

Application number	DE 10 2019 001 442
Patent applicant	TU Dortmund University
Status	Filed
Inventors	F. Kolpak • O. Hering • A. E. Tekkaya

The invention refers to a new testing device for the characterization of materials in the field of bulk metal forming. The device enables to form cube-shaped or cuboid specimens by applying a two-sided, biaxial pressure. Consequently, the test specimens are elongated in the one remaining free direction. By measuring the forming force as well as the specimen elongation, the material's forming properties are quantified. The favorable resulting hydrostatic pressure allows for large strains. The special tool arrangement leads to a mutual synchronization, causing a minimization of undesirable frictional forces, which leads to a significant improvement of the force measurement.

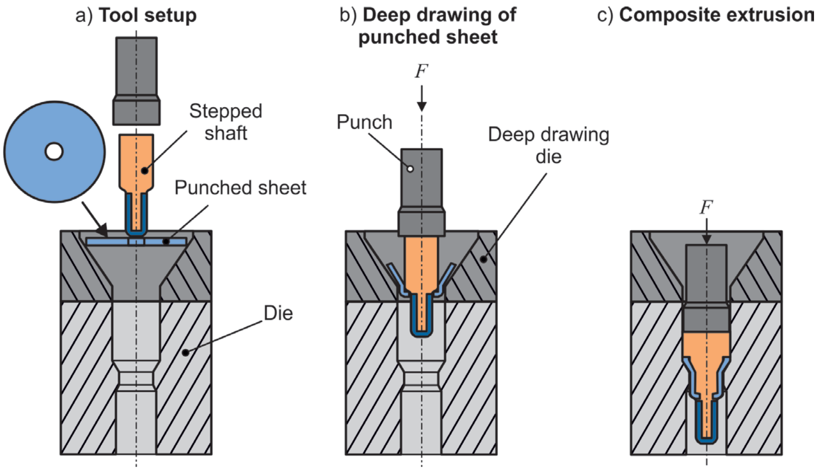


a) Sketch of the biaxial compression test device, b) Stress rate and strain state during biaxial compression

Process for the Production of Composite Parts by Combination of Sheet Expansion, Deep Drawing, and Forward Rod Extrusion

Application number	DE 10 2019 002 851.1
Patent applicant	TU Dortmund University
Status	Filed
Inventors	O. Napierala • M. Izydorczyk • O. Hering C. Dahnke • A. E. Tekkaya

The invention refers to a procedure and a tool setup for the production of composite components (a shaft consisting of a light metal core, e. g. aluminum, covered by a steel shell). By deep drawing of a punched steel sheet and subsequent forward rod extrusion, arbitrary shafts regions can be covered with the shell material. The investigation is an extension of the draw forging process. The flexibility of the process allows for a production of lightweight composite shafts that possess different surface properties in different regions, for example by combining various shell materials depending on the application requirements.

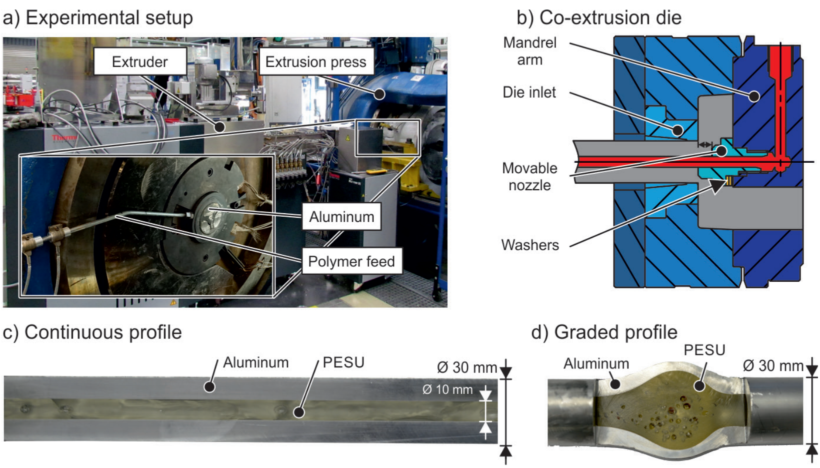


a) Tool setup, b) Deep drawing of punched sheet, c) Composite extrusion of shafts with varying surface properties

Method and Device for the Production of Aluminum-Polymer Profiles by Means of Extrusion

Application number	PCT/DE 2019/000058
Patent applicant	TU Dortmund University
Status	Filed
Inventors	J. Gebhard • C. Dahnke • A. Schulze N. Ben Khalifa • F. Günther • T. Kloppenborg M. Stommel • A. E. Tekkaya

The invention enables the intrinsic production of hybrid profiles made of aluminum and plastics. For this purpose, the forming process aluminum extrusion is combined with the molding process plastic extrusion by a modified porthole die. The polymer melt is fed into the extrusion die and injected into the forming zone of the aluminum (see Figure a and b). By adjusting the parameters ram speed, melt pressure, billet temperature, and profile cooling, the geometry of the profile (see Figure c) can be influenced. Additionally, profiles with a graded geometry can be produced (see Figure d). Depending on the extrusion parameters, the inner geometry, meaning the shape of the polymer core, and the outer geometry can be influenced. The combined extrusion process was successfully performed and both profiles with graded and with continuous cross sections were produced.



a) Experimental setup, b) Modified porthole die, c) Continuous and d) Graded profile

Further Activities

03

3 Further Activities

3.1 Conferences and Meetings

In 2019, several conferences and workshops were hosted or co-organized by the Institute of Forming Technology and Lightweight Components to present research results and to meet researchers from industry and universities. In the following, you will find more information on selected events.

Meeting of the IUL Industrial Advisory Board

Representatives of various industrial companies and forming technology associations met with representatives of the institute on May 10 and November 29 to discuss current developments. This year, hybrid components and the current research areas of polymer technology were the focus of the discussion: A lecture by Mr. Felder from “Kunststoffinstitut Lüdenscheid GmbH” on the various development focus areas of polymer materials was supplemented by Prof. Levy from the company “Technology Turn Around” who outlined the development of additive manufacturing for both polymer and metallic materials in his presentation. For the IUL, Prof. Tekkaya presented current research topics and future, partly visionary application areas of additive manufacturing developed at the institute.

But not only the development of new innovative manufacturing processes, but also the exact prediction of already known processes through a deep process understanding and numerical methods is indispensable for industry and faculty alike. A lecture by Dr. Schafstall was dedicated precisely to this topic and provided an overview of the challenges faced by companies in simulation technology. Prof. Tekkaya rounded off this topic with an overview of the possibilities of numerical methods. The regular exchange of information in the committee gives the companies insights into the institute’s current research projects and provides valuable input for future projects. Thanks to the Industrial Advisory Board new research projects on industry-relevant topics have been developed and, in further cooperation, investigated in an industry-related way. Meanwhile, 22 companies and associations are permanent members of the Advisory Board.

Visit of Baosteel delegation

High-ranked representatives of Baoshan Iron & Steel Co. Ltd. (Baosteel) visited research labs of the Faculty of Mechanical Engineering at TU Dortmund University on September 5, 2019. Prof. Tekkaya had invited the guests from the European research and development department of the Chinese company to exchange their ideas on future collaborations together with representatives from the Department of Materials Testing (Prof. Frank Walther, Anke Schmiedt-Kalenborn) and the Chair of Materials Technology (Dr. Ingor Baumann, Dr. Lukas Wojarski). The signing of a cooperation agreement in the field of material characterization and forming simulation for high-strength steels provided an occasion for the visit. Baosteel is the second largest steel manufacturer in the world by production volume. The technical discussions were accompanied by discussions on possible cooperations in the field of education. Representatives of the recorate, the international office, and the dean's office participated in the event.

Weiliang Huang, Director of Baosteel Strategy and Sci-Tech Management, and Prof. A. Erman Tekkaya signing the contract

Staff Excursion

A constant exchange of knowledge is an essential precondition for innovations at the IUL. For this purpose, the Institute for Forming Technology and Lightweight Components made an excursion to Davensberg in September. 32 employees played "Swingolf" in small groups as a social activity to enhance the team spirit. "Swingolf" is a variant of golf played with only one club and larger, softer balls. Even though the game ended for most participants with a rate of strokes well above par, it was a fun event, not least owing to the fabulous weather. Afterwards, the staff members enjoyed lunch together and took the chance to exchange views on current research topics and industrial challenges in the field of forming technology. The trip ended in the late afternoon with a relaxed return to Dortmund.

Group photo of the IUL employees during the SwinGolf game

ICFG International Paper Prize 2019

Felix Kolpak, IUL research assistant, participated in the 52nd Plenary Meeting of the International Cold Forging Group (ICFG) which took place from September 15 – 18, 2019 in San Sebastián, Spain. Mr. Kolpak won the "ICFG International Prize 2019", a prize being awarded annually to young scientists for outstanding research results in the field of cold forging.

He was awarded the prize for his research on the production of lightweight shafts utilizing cold forging. For this, the process of composite extrusion is used, where a steel shell is filled with a granular medium, e.g. quartz sand or zirconia beads, and subsequently cold-extruded together as a composite. After the extrusion step the granular medium can be removed and reused. In contrast to time and cost-consuming machining processes, the new process combination utilizes the advantages of cold forging and allows for the production of complex parts with undercuts.

Felix Kolpak, IUL, and Masahito Yamanaka, ICFG Chairman
Photo: Yoshinori Yoshida

Furthermore, the IUL participated in the following events, some of which were also open to a non-scientific audience of different target groups:

- Engineers-without-Borders • February 5
- Girls'Day 2019 • March 28
- MinTU • June 6
- Student competition “Stahl fliegt” (Flying steel) • June 25-26
- do-camp-ing • July 14-19
- SchnupperUni • August 21-22
- Open Day of TU Dortmund University • November 23

3.2 Participation in National and International Organizations: Prof. Dr.-Ing. A. Erman Tekkaya

Honors

- Honorary Professor of Xi'an Jiaotong University

Memberships of Research Boards

- acatech – Member of the "German Academy of Science and Engineering" ("Deutsche Akademie der Technikwissenschaften")
- AGU – Chairman of the "German Metal Forming Association" ("Wissenschaftliche Arbeitsgemeinschaft Umformtechnik")
- CIRP – Fellow of "The International Academy for Production Engineering"
- Council member of the "European Society of Experimental Mechanics"
- Curatorship member of "KARL-KOLLE Stiftung", Dortmund, Germany
- DGM – Member of "Deutsche Gesellschaft für Materialkunde"
- FOSTA – Member of the Advisory Board of the "German Steel Federation" ("Forschungsvereinigung Stahlanwendungen e. V.")
- GCFG – Member of the "German Cold Forging Group"
- I^2FG – Member of the "International Impulse Forging Group"
- ICFG – Member of the "International Cold Forging Group"
- ICTP – Advisory Member of the Standing Advisory Board of the "International Conference on Technology of Plasticity"
- JSTP – Member of the "Japan Society for Technology of Plasticity"
- Member of "DGM-Regionalforum Rhein-Ruhr"
- MPIE – Member of the Scientific Advisory Board of the "Max-Planck-Institut für Eisenforschung"
- Vice president of the german consortium of "Türkisch-Deutsche Universität" (Turkish-German University)
- WGP – Member of the "German Academic Society for Production Engineering" ("Wissenschaftliche Gesellschaft für Produktionstechnik")

Journals/Editorship

- Chairman of the Editorial Committee, "CIRP Annals"
- Member of the Editorial Board, "CIRP Journal of Manufacturing Science and Technology" (Elsevier)

- Member of the Editorial Board, "Journal of Production Processes and Systems"
- Member of the Editorial Board, "Materials"
- Member of the International Advisory Committee, "International Journal of Material Forming" (Springer)
- Member of the Scientific Editorial Board, "Computer Methods in Materials Science"
- Member of the Scientific Editorial Board, "International Journal of Precision Engineering and Manufacturing"
- Member of the Scientific Editorial Board, "Romanian Journal of Technical Sciences – Applied Mechanics"

Further Memberships

- Member of the Advisory Committee, "The 13th International Conference on the Technology of Plasticity" (ICTP 2020), Columbus, USA
- Member of the CIRP Communication Committee
- Member of the Scientific Committee, "The 12th International Conference and Workshop on Numerical Simulation of 3D Sheet Metal Forming Processes" (NUMISHEET 2020), Toronto, Canada
- Member of the Scientific Committee, "International Deep Drawing Research Group 2019" (IDDRG), Enschede, The Netherlands
- Member of the Scientific Committee, "International Deep Drawing Research Group 2020" (IDDRG), Busan, South Korea
- Member of the Scientific Committee, "The 13th International Conference on Numerical Methods in Industrial Forming Processes" (NUMIFORM 2019), Portsmouth, USA
- Member of the Scientific Committe, "1st International Conference on Advanced Joining Processes 2019" (AJP), Ponta Delgada, Portugal
- Member of the Standing Advisory Board, "The 13th International Conference on the Technology of Plasticity" (ICTP 2020), Columbus, USA

Activities as Reviewer In Scientific Committees

- AiF – Arbeitsgemeinschaft industrieller Forschungsvereinigung "Otto von Guericke" e. V.
- CIRP – International Academy for Production Engineering

- DFG – German Research Foundation, Member of Fachkolleqium 401 (Review Board on Production Engineering)
- ESF College of Expert Reviewers
- Massachusetts Institute of Technology, Boston, USA
- Max-Planck-Institut für Eisenforschung GmbH, Düsseldorf
- Middle Eastern Technical University, Ankara
- National Research Council Canada
- Oakland University, USA
- Steel Institute VDEh
- The Ohio State University, USA
- University of Cambridge, UK
- University of Cyprus
- WGP – German Academic Society for Production Engineering
- Xi'an Jiaotong University

For Journals

- Acta Materialia
- Advanced Manufacturing Technology
- Applied Mathematical Modelling
- ASME – Journal of Manufacturing Science and Engineering
- Archive of Applied Mechanics
- CIRP Annals – Manufacturing Technology
- Computational Materials Science
- Computer Methods in Applied Mechanics and Engineering
- Engineering Applications of Artificial Intelligence
- Engineering Computations
- Engineering with Computers
- Forschung im Ingenieurwesen
- HTM Journal of Heat Treatment and Materials
- International Journal for Numerical Methods in Engineering
- International Journal of Advanced Manufacturing Technology
- International Journal of Damage Mechanics
- International Journal of Machine Tools and Manufacture
- International Journal of Materials and Product Technology

- International Journal of Material Forming
- International Journal of Mechanical Sciences
- International Journal of Mechanics and Materials
- International Journal of Precision Engineering and Manufacturing
- International Journal of Solids and Structures
- Journal Material Characterization – An International Journal on Materials Structure and Behavior
- Journal of Applied Mathematical Methods
- Journal of Computational and Applied Mathematics
- Journal of Manufacturing Processes
- Journal of Manufacturing Science and Engineering
- Journal of Materials Processing Technology
- Journal of Mechanical Engineering
- Journal of Pressure Vessel Technology
- Journal of Production Engineering
- Manufacturing Letters
- Materials
- Materials & Design
- Materials and Manufacturing Processes
- Materials Science and Engineering A
- Mechanics of Materials
- Simulation Modelling Practice and Theory
- Steel Research International
- Strain: An International Journal for Experimental Mechanics
- Surface and Coatings Technology
- The International Journal of Advanced Manufacturing Technology

3.3 Participation in National and International Organizations: Prof. Dr.-Ing. Dr. h.c. Matthias Kleiner

Scientific Academies

- Academia Europaea
- acatech – Council of Technical Sciences of the German Academy of Science and Engineering
- Berlin-Brandenburg Academy of Science and Humanity
- CIRP – The International Academy for Production Engineering
- German Academy of Natural Scientists Leopoldina
- European Academy of Sciences and Arts
- Indian National Science Academy
- Russian Academy of Engineering
- Swiss Academy of Engineering Sciences

Advisory Boards

- Global Learning Council, Chair
- Open Science Policy Platform
- STS Council and Board – STS-Forum Science and Technology in Society, Japan
- Member of the Supervisory Board Futurium gGmbH
- Advisory Committee Japan Science and Technology Agency (JST) Tokyo
- Board of Trustees, Max Planck-Institute of Molecular Cell Biology and Genetics, Dresden
- International Advisory Board for the Development of Competence Centers on Artificial Intelligence Research in Germany, chair

University Advisory Boards

- Chairman of the University Council, Johann Wolfgang Goethe-University, Frankfurt
- Excellence Initiative Board, Bremen University
- Board of Trustees, TU Berlin
- Board of Trustees, Julius Maximilian-University Würzburg
- International Advisory Board Faculty of Engineering, Twente University

Foundation Advisory Boards

- Board of Trustees, Deutsche Telekom Foundation
- Board of Trustees, Daimler und Benz Foundation
- Scientific Advisory Board, Fritz Thyssen Foundation
- Scientific Advisory Board of the Excellence Initiative Johanna Quandt – Charité Foundation
- Advisory Board, Werner Siemens-Stiftung, Switzerland

Professional Chairs

- AGU – Working Group on Forming Technology
- WGP – German Academic Society for Production Engineering
- Board of Trustees, FOSTA Research Association for Steel Application

Consultant and Advisory Board

- Tang Prize International Advisory Board, Taipei
- Member of the Jury for the “Deutscher Innovationspreis”
- Member of the Jury of the Georg von Holtzbrinck Prize for Science Journalism
- Board of Trustees of the “Zukunftspreis” of the Federal President

Cooperation Advisory Boards

- Advisory Board, ALHO Holding
- Advisory Board, Siepmann Werke
- Advisory Board, Winkelmann Group

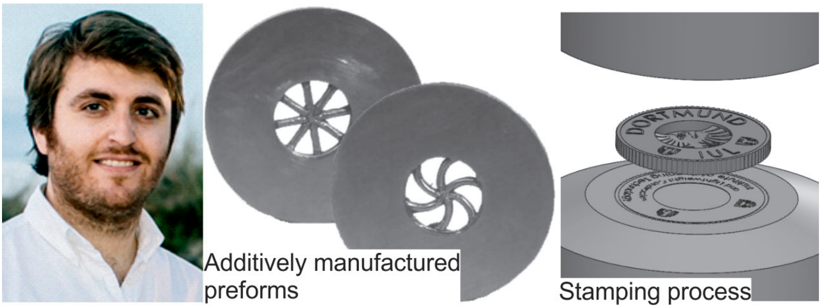
International Exchange

04

4 International Exchange

Prof. Carlos Manuel Alves da Silva

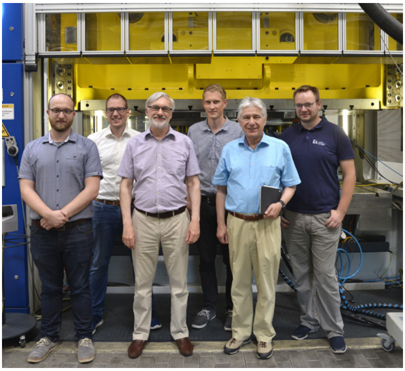
Prof. Carlos Manuel Alves da Silva, Assistant Professor in the working group of Prof. Paulo Martins, Instituto Superior Técnico, Technical University of Lisbon, visited the IUL from May to June 2019. During his research visit Prof. Silva dealt with the link between forming technology and additive manufacturing. The idea consists of the additive production of coin blanks with complex geometries, which can also protrude from the coin level. A subsequent embossing operation is made to produce the final commemorative coin. To test the production strategy, blanks made of a stainless steel alloy were produced generatively using selective laser melting. Furthermore, Prof. Silva has numerically examined the material flow in the embossing process with a focus on the design of the preform. He also developed an analytical model for the prediction of the deformation behavior of the internal coin structure. For the correct prediction of the embossing operation, Prof. Silva characterized the additively manufactured material with regard to its formability.



Prof. C. Silva, additively manufactured preforms, embossing tool with a coin

Renowned expert for plasticity from South Korea at the IUL

Prof. Frédéric Barlat from the Graduate Institute of Ferrous Technology at Pohang University of Science and Technology in South Korea visited the IUL from July 23 to 27, 2019. The internationally renowned expert for anisotropic plasticity visited the experimental hall and discussed current research in the fields of material characterization for plasticity and damage with Prof. Tekkaya, Dr. Clausmeyer, Dr. Löbbe, F. Gutknecht, and F. Kolpak. Prof. Barlat provided important advice to the IUL concerning modeling of anisotropy and the Bauschinger effect. He was enthusiastic about the innovations of new forming processes at the institute. He works with his doctoral student on the application of servo presses for novel forming processes. Therefore, he was very interested in the current research on the application of transfer tools on a servo press. The IUL staff members are looking forward to Prof. Barlat's longer stay in the summer of 2020.



F. Kolpak, Dr. T. Clausmeyer, Prof. F. Barlat, Dr. C. Löbbe, Prof. A. E. Tekkaya, F. Gutknecht (from left to right) in the experimental hall

Prof. Christopher Saldana

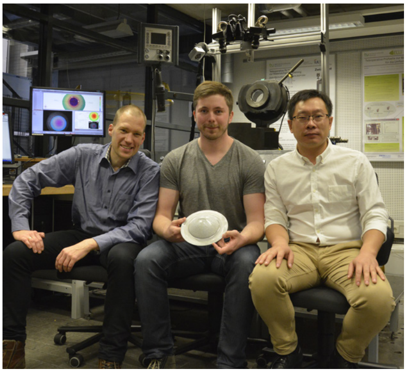
In October 2019, Prof. Christopher Saldana from the Georgia Institute of Technology (GA. Tech) visited the IUL, funded by the Gambrinus Fellowship of TU Dortmund University. The Gambrinus Fellowship promotes the development of new contacts of TU Dortmund University with international guests for collaborative research. In this context, Prof. Saldana gave a public lecture entitled "Understanding deformation and failure of heterogeneous materials using in-situ computed tomography". During his stay, possible collaborations in current and planned research projects of the IUL and the working group of Prof. Saldana were discussed and evaluated, which led to multiple interesting project ideas. A first collaboration is the investigation of additively manufactured sandwich metal composites whose deformation behavior within the core layer is investigated with the help of computed tomography. The results of the collaboration will be presented as part of a publication and a presentation at the conference ICTP 2020 in Ohio.

Prof. C. Saldana, E. Jost, Dr. T. Clausmeyer, Prof. A. E. Tekkaya, S. Rosenthal (from left to right)

Prof. Kaan Inal presents lectures on artificial intelligence in forming technology

Prof. Kaan Inal from the University of Waterloo in Canda conveyed important current methods of artificial intelligence and material modeling during his stay from September 16 to 19, 2019. He presented his research findings of the last ten years on the application of artificial intelligence in the design of forming processes for the automobile industry and the improvement of the modeling for light metals. In his research he benefits from his fundamental works on computational modeling, but also from his long-term cooperation with industry, currently as the director of the Waterloo Center for Automotive Research (WatCAR). On the basis of the exchange after his lectures, the IUL research staff and Prof. Inal plan to work together on material characterization and numerical modeling.

Short visit of Humboldt scholar Prof. Yanshan Lou

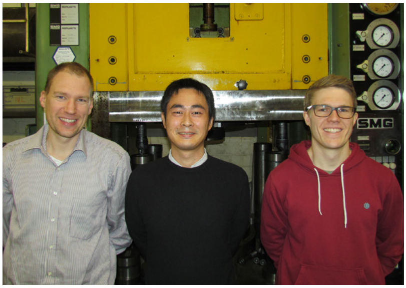


Dr. T. Clausmeyer, F. Stiebert, Prof. Y. Lou (from left to right) in the testing room of the IUL in front of a machine for sheet testing and the teleoperative testing cell

Prof. Yanshan Lou from the School of Mechanical Engineering at the Xi'an Jiatong University in China conducted experiments for the material characterization from October 14 until October 16, with the testing facilities of the IUL. He had already collaborated closely with the members of the Applied Mechanics group on modeling of failure during his stay as Alexander von Humboldt scholar from 2014 until 2015. He has published a number of highly cited articles on ductile fracture in metals in renowned journals at an early stage of his career. He carried out hydraulic bulge tests on aluminum alloys and high-strength steels during his stay. Dr. Till Clausmeyer and Fabian Stiebert supported him during his work.

Joint research on cold extrusion with Yasuhisa Taki

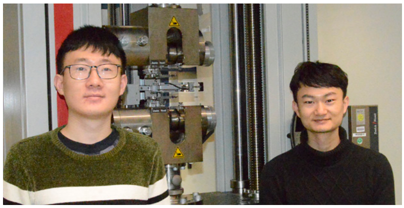
The Japanese visiting scientist Yasuhisa "Yasu" Taki investigates the behavior of steel and aluminum during cold forward extrusion since September 2019. He developed the plan to work at the IUL for some time, after his colleagues from Kobe Steel and he had heard about the research results of the DFG Collaborative Research Centre TRR 188 on the development of damage in cold forward extrusion. His research stay takes place in the wider context of a research cooperation with Kobe Steel, Ltd. The Department of Bulk Metal Forming is interested in obtaining first-hand knowledge from industry on bulk metal forming.



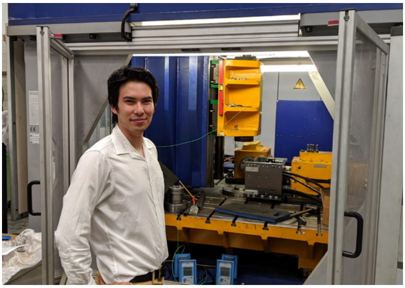
Dr. T. Clausmeyer, Y. Taki and R. Gitschel (from left to right) in front of the SMG extrusion press

The connoisseur of Porsche cars and passionate jazz trumpeter has already participated in several activities at the institute, such as a seminar on intercultural collaboration and a joint visit of a match of Germany‘s national soccer team. He will conduct research at the TU Dortmund University until August 2020 and is looking forward to getting to know Dortmund and Germany even better together with his wife.

Yifan Du and Liang Zhong

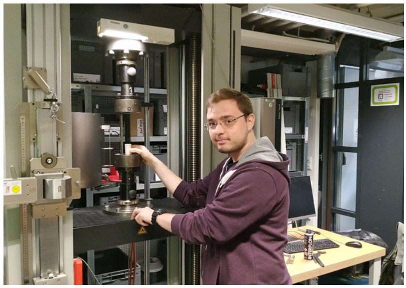

L. Zhong (left) and Y. Du in front of the universal testing machine

Two exchange students participating in the bachelor program of Prof. Yanshan Lou from Xi’an Jiaotong University in China performed research at the IUL for three months. In the period from January to April, they dealt with the damage behavior of high-strength sheet materials and worked intensively on damage characterization. The investigations provided information on the damage evolution for different loading conditions. The two students were supervised by colleagues from the Applied Mechanics group during their stay. In particular, the gathered data under pure shear load obtained in the in-plane shear tests was interesting for the determination of yield curves. At their home university this data is also used for the determination of fracture locus curves.


RISE student K. Kamiya

RISE (Research Internships in Science and Engineering) – Kenzo Kamiya

As in previous years, the IUL took part in the program “RISE” of the German Academic Exchange Service (DAAD) in 2019. From May until August, Kenzo Kamiya from the Purdue University (West Lafayette, Indiana, USA) visited the IUL. The RISE program gives Bachelor students from the UK and North America the opportunity to do internships at German research institutions. The stay of Mr. Kamiya was financed by a grant collectively funded by the DAAD and the DFG Collaborative Research Center Transregio 73. Under the supervision of Mr. Wernicke, Mr. Kamiya was engaged in the topic of incremental sheet-bulk metal forming. This technique enables the efficient manufacture of functional components featuring a load-adapted shape. Mr. Kamiya conducted experimental and numerical investigations on electrically-assisted forming of gears. For example, he programmed a MATLAB script for the evaluation of measured data. The utilization of this script significantly reduces the effort needed for the analysis of data for further experiments.


Erasmus exchange student M. Boztepe at an universal testing machine

Erasmus Scholar – Furkan Mahmut Boztepe

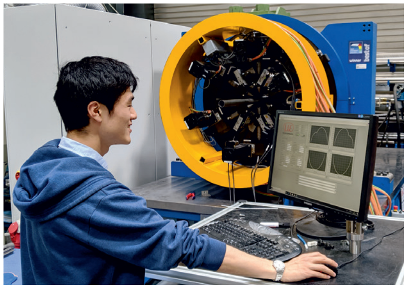
From July to September 2019 Mr. Mahmut Boztepe from the TED University in Ankara visited the IUL. He was supported by the “Erasmus+” foundation. As part of his scientific internship in the department of massive forming, Mr. Boztepe investigated the suitability of different plastic modeling materials for physical process modeling. The aim was to characterize the model materials for different strain rates in order to assess the similarity with aluminum under aluminum hot extrusion conditions. The investigations showed that the preparation of the samples, in particular the processing temperature, has a major influence on the material characteristics. In addition, it could be proven that the model material has an increasing yield stress with increasing strain rate. Based on the findings, the results of material characterization can be transferred to the material

L. Meise in front of the machine frame which will later house the bending as well as the rolling unit for the novel profile bending machine

aluminum and physical process simulation can be used to investigate the material flow or process forces for new extrusion processes.

Exchange with Lehigh University

For the first time, the IUL welcomed an exchange student from Lehigh University in Bethlehem, Pennsylvania. Ms. Lexi Meise visited the institute for about 10 weeks through the Lehigh Iacocca International Internship Program. During her research internship she assisted her supervisor, Mr. Juri Martschin, in developing a program which would convert CAD files of a given geometry into path data for a machine. That machine was the novel flexible profile forming with superimposed pressure by rolling. It is currently under development and will, in the future, be able to bend profiles with a rectangular cross section. Given her background in computational engineering, Ms. Meise could help to further advance the development of the machine.

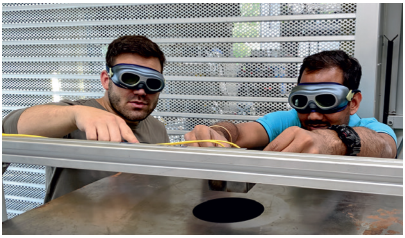


R. Nakahata performing first trials on the upgraded IPF machine

Exchange with The Ohio State University

Through the NSF-funded exchange program "Forming and manufacture of lightweight high-performance components – International Research Experiences for Students at the TU Dortmund University", a maximum of five students from The Ohio State University (OSU) per year get the chance to do an exchange research internship at the IUL during the summer break. Due to the close supervision by a scientific assistant of the institute the students were able to gain detailed insight into the research practices at a leading German manufacturing research institute. Moreover, the program supports the social-culture development of the students in order to further strengthen future collaborations with the OSU and other US institutes as well. This year, a total of two students from the OSU visited the IUL during the summer.

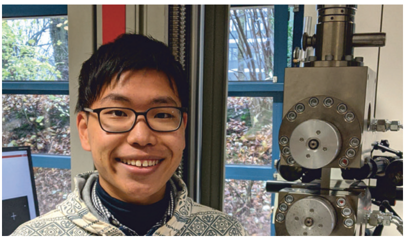
Mr. Ryo Nakahata visited the IUL for the second time after he started working on the incremental profile forming (IPF) machine last summer. Based on last year's preparatory work, he continued with the development of a closed-loop control for the machine. For this purpose, he installed two laser scanners which gather the required geometry data for the control system.



A. Kapil (right) together with his supervisor M. Hahn installing the new sensor system

With this data, deviations of the current profile cross-section can be detected, such that the control mechanism can adjust the process parameters for the next increment. The implementation of the data is still part of ongoing research.

Laser sensors were also the major aspect of Mr. Angshuman Kapil's work, the second exchange student from The Ohio State University. He analyzed the velocities of the accelerated workpiece during the high speed forming process utilizing vaporizing aluminum foils. For this purpose, the sensors are placed above of the shielding chamber in which the forming operation takes place. The gathered data will be used to validate numerical as well as analytical models which are currently being developed at both institutes.



Y. Takaya in front of the tensile/compression machine which is used to conduct his specially designed experiments

Exchange with The Ohio State University

As part of the annual exchange program between the IUL and the G-CADET facility at the Gifu University in Japan, Mr. Yusuke Takaya joined our institute to conduct several experiments for his master thesis. As part of Prof. Y. Yoshida's team, who runs the exchange program at the Gifu University, he uses a digital image correlation system to track the three-dimensional geometry of compression test specimens. The final data will be used to calibrate advanced material models for FEM simulations. As part of the bilateral exchange program, Mr. Fabian Stiebert will participate in the G-CADET program at the Gifu University. Additionally, he will assist in ongoing research in the field of a process combination of SLM and forming technologies.

Technical Equipment

05

5 Technical Equipment

Experimental Area

Presses

- 10 MN (direct) extrusion press, suitable for curved profile extrusion, SMS Meer
- Adiabatic blanking machine, AdiaClip 1000 J, MPM Émalec
- Blanking- and forming press with servo drive, 4000 kN, Schuler MSD2-400
- C-frame eccentric press, 630 kN, Schuler PDR 63/250
- Extrusion press 2.5 MN, Collin, LPA 250 t
- Hydraulic drawing press, 10 MN triple action, M+W BZE 1000-30.1.1
- Hydraulic drawing press, 1000 kN, HYDRAP HPSZK 100-1000/650
- Hydraulic drawing press, 2600 kN, triple action, SMG HZPUI 260/160-1000/1000
- Press for working media-based sheet metal forming, 100 MN, SPS

Further Forming Machines

- CNC rotary draw bending machine, DB 2060-CNC-SE-F, Transfluid Maschinenbau GmbH
- DMU 50 – 5-axis milling maschine, DMG Mori
- Hydraulic punching machine TruPunch 5000, 220 kN – TRUMPF Werkzeugmaschinen GmbH & Co. KG
- Machine for electromagnetic forming, 1.5 kJ, PPT SMU 1500 (recuperationable), self-built at IUL
- Machine for electromagnetic forming, 32 kJ, Maxwell Magneform 7000
- Machine for electromagnetic forming, 6 kJ, Poynting SMU 0612 FS
- Machine for incremental profile forming, self-built at IUL
- Machine for incremental tube forming, IRU2590, transfluid Maschinenbau GmbH
- Multi-axes forming press TR 73, 100 kN, prototype with five axes of motion (Schnupp Hydraulik)

- Press brake, 1300 kN, TrumaBend V 1300X
- Profile bending machine TSS-3D, self-built at IUL
- Roll forming machine RAS 24.10, Reinhardt Maschinenbau GmbH, Sindelfingen
- Spinning machine, Leifeld APED 350NC, CNC Siemens 840 D
- Swivel bending machine, FASTI 2095

Additive Manufacturing Machines

- Combined 5-axis machining and laser deposition welding center Lasertec 65 3D, Sauer GmbH/DMG MORI
- FDM-based 3D printers for thermoplastic materials (2x Ultimaker 3, 1x Ultimaker 3 Extended, 1x Creality Ender 5)
- Powder bed machine for additive manufacturing DMG MORI “Lasertec 30 SLM“

Material Testing Machines

- Bulge-testing machine, 200 kN, Erichsen 142/20
- five Universal testing machines, Zwick 1475 100 kN, Zwick SMZ250/ SN5A, Zwick FR250SN.A4K, Allround Line, Zwick Z250 (2 x)
- Plastometer, 1 MN, self-built
- Roughness Tester Marsurf XR1, Roughness measuring station with drive unit GD26, company Mahr
- Sheet metal testing machine Zwick BUP1000

Measurement Technique and Electronics

- 3D-coordinate measurement machine, Zeiss PRISMO VAST 5 HTG (in cooperation with the “Institute of Machining Technology”, TU Dortmund University)
- 3D-video measuring system, Optomess A250
- 3MA-II measurement system
- Density measurement system, IMETER V6 by MSB Breitwieser MessSysteme
- Digital Oscilloscope, 4 channels, LeCroy HDO6104A

- Digital Oscilloscope, 4 channels, LeCroy Waverunner 104 MX
- Hardness tester, Wolpert Diatestor 2 RC/S
- Infrared Camera, Infratec VarioCam HD head 680 S, Resolution 1280 x 960 Pixel
- Infrared measuring device, PYROSKOP 273 C
- Keyence Laser: non-contact distance measurement
- Large volume SEM, Mira XI by Visitec (in cooperation with the "Institute of Machining Technology" and „Lehrstuhl für Werkstofftechnologie", TU Dortmund University)
- Laser Surface Velocimeter (LSV): non-contact velocity measurement
- Laser-based Photon-Doppler Velocimeter for the measurement of high workpiece velocities
- Light optical microscope AxioImager.M1m adapted for polarization, Zeiss AG
- Milling Guide RS-200 for the determination of residual stresses by means of hole drilling technique and strain gauge measurements
- Digital storage oscilloscope, 4 measuring channels, Tektronix TDS 420A
- Multi-wavelength pyrometer, Williamson pro 100 series
- Near infrared pyrometer, Sensortherm Metis M 316
- Near infrared pyrometer, Sensotherm Metis M 318
- Optical 3D deformation analysis: GOM ARAMIS 5 M (2 x) and 4 M (1 x), GOM ARGUS
- Optical 3D digitizer: GOM ATOS Triple Scan (2 x), GOM TRITOP
- Optical 3D motion analysis: GOM PONTOS 4M
- Optical frequency domain reflectometer ODiSI-B10 by Polytec: System for the space- and time-resolved measurement of temperature and strain
- StressTech Prism – Residual stress measurement by means of hole-drilling technique and Electronic Speckle Pattern Interferometry (ESPI)
- Stresstech Xstress 3000 – X-ray diffractometer for measuring residual stresses
- Thickness measuring device, Krautkrämer CL 304

Miscellaneous

- 6-axes robot, industrial robot KUKA KR 90 R3700 prime K
- 6-axes robot, industrial robot KUKA-KR 5 sixx R650

- Belt grinding machine, Baier PB-1200-100S
- DC power supply LAB4020
- different machines for machining purposes
- Etching and polishing station – LectoPol-5, Struers GmbH
- High-frequency generator, 10 kW, Hüttinger Axio 10/450
- High-performance metal circular saw, Häberle AL 380
- Hydraulic power units and pressure intensifiers up to 4000 bar (3 x)
- Hydrostatic roller burnishing tool, Ecoroll, HG13 and HG6
- Industrial robot KUKA KR 30-3
- Laser processing center, Trumpf LASERCELL TLC 1005
- Measuring rack, Boxdorf HP-4-2082
- Medium-frequency generator, 40 kW, Trumpf TruHeat 3040 und 7040, with coax transformer
- Mitring band sawing machines, Klaeger HBS 265 DG
- Roll seam welding machine, Elektro-Schweißtechnik Dresden UN 63 pn
- Tabletop cut-off machine Discotom-100, Struers (in cooperation with the “Institute of Machining Technology”, TU Dortmund University)
- Tensile testing grinder, Schütz + Licht GmbH, PSM 2000
- Tensile testing punch press, 1200 kN, Schütz + Licht GmbH ZS1200CN
- Turning machine, Weiler Condor VS2

Technical Equipment

05

Kooperationen | Cooperations

06

Kooperationen | Cooperations

Auf diesem Wege möchten wir uns für die vielfältige Zusammenarbeit im Jahr 2019 bedanken, ohne die unser gemeinsamer Erfolg nicht möglich wäre.

At this point we would like to express our gratitude to the large number of various cooperation partners in 2019 which have added to our joint success.

Industriebeirat des IUL | IUL Industrial Advisory Board

Das Gremium des Industriebeirates vermittelte auch im Jahr 2019 wichtige Impulse hinsichtlich des industriellen Forschungsbedarfes. An dieser Stelle möchten wir uns für diese wertvolle Zusammenarbeit bedanken.

In 2019, the Industrial Advisory Council provided yet again significant input regarding the need for research from an industrial point of view. We would like to take this opportunity to express our gratitude for this valuable cooperation.

- Gerhard Bürstner, Ing.-Büro Gerhard Bürstner
- Marius Fedler, Kunststoff-Institut für die mittelständische Wirtschaft NRW GmbH
- Dr. Frank O. R. Fischer, Deutsche Gesellschaft für Materialkunde e. V.
- Dr. Georgios Georgiadis, Volkswagen AG
- Rainer Hank, TRUMPF Werkzeugmaschinen GmbH & Co. KG
- Dr. Jens Heidenreich, PHOENIX FEINBAU GmbH & Co. KG
- Wolfgang Heidrich, GDA – Gesamtverband der Aluminiumindustrie e. V.
- Jörg Höppner, Verband Metallverpackungen e. V.
- Franz Jurt, Feintool Technologie AG
- Dr. Stefan Keller, Hydro Aluminium Rolled Products GmbH
- Dr. Lutz Keßler, ThyssenKrupp Steel Europe AG
- Dr. Lukas Kwiatkowski, Otto Fuchs KG
- Prof. Gideon Levy, TTA – Technology Turn Around
- Dr. Hans Mulder, Tata Steel Research & Development Product Application Centre
- Franz-Bernd Pauli, Franz Pauli GmbH & Co. KG
- Rainer Salomon, Forschungsvereinigung Stahlanwendung e. V. (FOSTA)
- Dr. Hendrik Schafstall, simufact engineering GmbH
- Dr. Eduard Schenuit, Zwick GmbH & Co. KG
- Prof. Karl Schweizerhof, DYNAmore GmbH
- Dr. Hosen Sulaiman, Faurecia Autositze GmbH
- Mario Syhre, GKN Driveline Deutschland GmbH
- Adolf Edler von Graeve, KIST Kompetenz- und Innovationszentrum für die StanzTechnologie Dortmund e. V.

Universitäre Kooperationen auf nationaler Ebene | University cooperations at national level

- Chair of Micromechanical and Macroscopic Modelling, ICAMS, Ruhr-Universität Bochum
- Cybernetics Lab IMA & IfU, Rheinisch-Westfälische Technische Hochschule Aachen
- Fachgebiet Maschinenelemente, Technische Universität Dortmund
- Fachgebiet Metallische Werkstoffe, Institut für Werkstoffwissenschaften und -technologien, TU Berlin
- Fachgebiet Werkstoffprüftechnik, Technische Universität Dortmund
- Fachhochschule Südwestfalen
- Fraunhofer-Institut für Werkstoff- und Strahltechnik IWS, Dresden
- Fraunhofer-Institut für Werkzeugmaschinen und Umformtechnik IWU, Technische Universität Chemnitz
- Fraunhofer-Projektgruppe am Dortmunder Oberflächen-Centrum DOC, Dortmund
- Gemeinschaftslabor für Elektronenmikroskopie, Rheinisch-Westfälische Technische Hochschule Aachen
- IngenieurDidaktik, Technische Universität Dortmund
- Institut für Angewandte Materialien – Werkstoffkunde, Karlsruher Institut für Technologie (KIT)
- Institut für Bildsame Formgebung, Rheinisch-Westfälische Technische Hochschule Aachen
- Institut für Eisenhüttenkunde, Lehr- und Forschungsgebiet für Werkstoff- und Bauteilintegrität, Rheinisch-Westfälische Technische Hochschule Aachen
- Institut für Fertigungstechnik und Werkzeugmaschinen, Leibniz Universität Hannover
- Institut für Kunststoffverarbeitung, Rheinisch-Westfälische Technische Hochschule Aachen
- Institut für Leichtbau und Kunststofftechnik, Technische Universität Dresden
- Institut für Mechanik der Bauwissenschaften, Universität Duisburg-Essen
- Institut für Mechanik, Technische Universität Dortmund
- Institut für Metallformung, Technische Universität Bergakademie Freiberg
- Institut für Metallurgie, Abteilung Werkstoffumformung, Technische Universität Clausthal-Zellerfeld
- Institut für Produktionstechnik und Umformmaschinen, Technische Universität Darmstadt
- Institut für Spanende Fertigung, Technische Universität Dortmund
- Institut für Umformtechnik und Umformmaschinen, Leibniz Universität Hannover
- Institut für Umformtechnik, Universität Stuttgart
- Institut für Werkstoffkunde, Leibniz Universität Hannover
- Institut für Werkzeugmaschinen und Betriebswissenschaften, Technische Universität München

- Institut für Werkzeugmaschinen und Fabrikbetrieb, Technische Universität Berlin
- Laboratorium für Werkstoff- und Fügetechnik, Universität Paderborn
- Lehrstuhl Baumechanik, Technische Universität Dortmund
- Lehrstuhl Fertigungstechnik, Universität Duisburg-Essen
- Lehrstuhl für Fertigungstechnologie, Friedrich-Alexander-Universität Erlangen-Nürnberg
- Lehrstuhl für Feststoffverfahrenstechnik, Ruhr-Universität Bochum
- Lehrstuhl für Konstruktion und Fertigung, Brandenburgische Technische Universität Cottbus-Senftenberg
- Lehrstuhl für Umformtechnik und Gießereiwesen, Technische Universität München
- Lehrstuhl für Umformtechnik, Universität Siegen
- Lehrstuhl für Werkstofftechnologie, Technische Universität Dortmund
- Lehrstuhl Hybrid Additive Manufacturing, Ruhr-Universität Bochum
- Lehrstuhl Werkstoffwissenschaft, Ruhr-Universität Bochum
- Max-Planck-Institut für Eisenforschung GmbH, Düsseldorf
- Professur für Baumechanik, Universität der Bundeswehr München
- Professur für Theoretische Elektrotechnik und Numerische Feldberechnung, Helmut-Schmidt-Universität, Universität der Bundeswehr Hamburg
- Professur Virtuelle Fertigungstechnik, Technische Universität Chemnitz
- Professur Werkstoffwissenschaft, Technische Universität Chemnitz
- wbk Institut für Produktionstechnik, Karlsruher Institut für Technologie
- Werkzeugmaschinenlabor, Rheinisch-Westfälische Technische Hochschule Aachen
- Zentrum für HochschulBildung (zhb), Technische Universität Dortmund

Universitäre Kooperationen auf internationaler Ebene | University cooperations at international level

- Department of Materials Science and Engineering, The Ohio State University, Ohio, USA
- Department of Mechanical Engineering, Gifu University, Yanagido, Japan
- Department of Mechanical Engineering, Instituto Superior Técnico, University of Lisbon, Portugal
- Department of Mechanical Engineering, Section of Manufacturing Engineering, Technical University of Denmark, Lyngby, Denmark
- Department of Mechanical Science and Engineering, Hiroshima University, Higashi-Hiroshima, Japan
- École Nationale Supérieure d'Arts et Métiers (ENSAM), ParisTech, Paris, France
- Institut Carnot ARTS, Université de Valenciennes et du Hainaut-Cambrésis, Valenciennes, France
- Institute for Manufacturing, Department of Engineering, University of Cambridge, UK
- KAIST – Korea Advanced Institute of Science and Technology, Daejeon, Republic of Korea
- KIMS – Korea Institute of Materials Science, Gyeongnam, Republic of Korea
- Laboratory of Microstructure Studies and Mechanics of Materials, Arts et Métiers ParisTech (Metz campus), France
- Mechanical Engineering College of Tongji University, Jiading Campus, Shanghai, China
- Nagoya University, Nagoya, Japan
- School of Mechatronics Engineering, Harbin Institute of Technology, Harbin, Heilongjiang, China
- Türkisch-Deutsche Universität, Istanbul, Turkey

Nationale und internationale Kooperationen im industriellen Umfeld | Industrial cooperations at national and international level

- Airbus Helicopters
- Alfred Konrad Veith GmbH & Co. KG
- alutec metal innovations GmbH & Co. KG
- AUDI AG
- AutoForm Engineering Deutschland GmbH
- Baoshan Iron & Steel Co. Ltd.
- Benteler International AG
- Bilstein GmbH & Co. KG
- BMW AG
- BÖHLER-UDDEHOLM Deutschland GmbH
- borit Leichtbau-Technik GmbH
- CARL BECHEM GMBH
- Centroplast Engineering Plastics GmbH
- C-TEC Constellium Technology Center
- Daimler AG
- data M Sheet Metal Solutions GmbH
- Deutsche Edelstahlwerke Specialty Steel GmbH & Co. KG
- DYNAmore GmbH
- ElringKlinger AG
- F. W. Brökelmann Aluminiumwerk GmbH & Co. KG
- Faurecia Group
- FLORA Wilh. Förster GmbH & Co. KG
- Franz Pauli GmbH & Co. KG
- Freudenberg Sealing Technologies GmbH & Co. KG
- FRIMO Group GmbH Composites & Tooling Technologies
- Gebr. Wielpütz GmbH & Co. KG
- Gerhardi AluTechnik GmbH
- Goekeler Messtechnik GmbH
- Grundfos GmbH
- GSU Schulungsgesellschaft für Stanz- und Umformtechnik mbH
- Heggemann AG
- HELLA GmbH & Co. KGaA
- Hirschvogel Umformtechnik GmbH
- HMT Höfer Metall Technik GmbH & Co. KG
- HoDforming GmbH
- HUECK Extrusion GmbH & Co. KG
- Hydro Aluminium Deutschland GmbH
- inpro Innovationsgesellschaft für fortgeschrittene Produktionssysteme in der Fahrzeugindustrie mbH
- JFE Steel Corporation
- Johnson Controls Hilchenbach GmbH
- Kirchhoff Automotive GmbH
- Kistler Instrumente AG
- KOBE STEEL, LTD.

- KODA Stanz- und Biegetechnik GmbH
- Kunststoff-Institut Lüdenscheid (KIMW GmbH)
- MATFEM Partnerschaft Dr. Gese & Oberhofer
- MK Metallfolien GmbH
- Mubea Unternehmensgruppe
- Otto Fuchs KG
- Outokumpu Nirosta GmbH
- Poynting GmbH
- PWF Aerospace GmbH
- S+C Extrusion Tooling Solutions GmbH
- Salzgitter Mannesmann Forschung GmbH
- Salzgitter Mannesmann Precision Tubes GmbH
- Schnupp GmbH & Co. Hydraulik KG
- Schondelmaier GmbH Presswerk
- Schuler AG
- Schwarze-Robitec GmbH
- simufact engineering gmbh
- SMS Meer GmbH
- SSAB Svenskt Stål AB
- STURM GmbH
- Tata Steel
- thyssenkrupp Steel Europe AG
- TM Lasertechnik GmbH
- transfluid Maschinenbau GmbH
- TRUMPF Hüttinger GmbH + Co. KG
- TRUMPF Werkzeugmaschinen GmbH + Co. KG
- Viessmann Werke GmbH & Co. KG
- voestalpine AG
- VOLKSWAGEN AG
- Vossloh AG
- wefa Westdeutsche Farben GmbH
- Welser Profile Deutschland GmbH
- Wilke Werkzeugbau GmbH & Co. KG
- WILO SE
- Zentrum für BrennstoffzellenTechnik GmbH

In addition, several companies with disclosure agreements.

Verbände | Associations

- acatech – Deutsche Akademie der Technikwissenschaften e. V.
- AGU – Arbeitsgemeinschaft Umformtechnik
- AiF Arbeitsgemeinschaft industrieller Forschungsvereinigungen „Otto von Guericke“ e. V.
- Aluminium-Leichtbaunetzwerk
- ASM International
- CAE – Chinese Academy of Engineering
- CIRP – The International Academy for Production Engineering
- DAAD - Deutscher Akademischer Austauschdienst e. V.
- DFG – Deutsche Forschungsgemeinschaft
- DGM – Deutsche Gesellschaft für Materialkunde e. V.
- EFB – Europäische Forschungsgesellschaft für Blechverarbeitung e. V.
- FGM – Fördergesellschaft Metallverpackungen mbH
- FOSTA – Forschungsvereinigung Stahlanwendung e. V.
- GCFG – German Cold Forging Group e. V.
- GDA – Gesamtverband der Aluminiumindustrie e. V.
- I^2FG – International Impulse Forming Group e. V.
- IBU – Industrieverband Blechumformung e. V.
- ICFG – International Cold Forging Group
- IDDRG – International Deep Drawing Research Group
- IMU – Industrieverband Massivumformung e. V.
- ITA – International Tube Association

Stiftungen | Foundations

- KARL-KOLLE-Stiftung
- Stifterverband Metalle e. V.
- VolkswagenStiftung
- Werner Richard – Dr. Carl Dörken Stiftung
- Wilo-Foundation

Abgeschlossene Arbeiten | Completed Theses

07

Abgeschlossene Masterarbeiten[1] | Completed Master of Science Theses[2]

Bandura, Philip
Tekkaya, A. E.; Weber, F.
Untersuchung des Spannungszustands und des Stoffflusses beim spannungsüberlagerten Rohrziehen mit fliegendem Dorn
Analysis of the stress state and material flow for stress-superposed tube drawing with flying mandrel

Bhattarai, Yogesh
Tekkaya, A. E.; Gutknecht, F.
Numerische Kantenrissvorhersage von Stanzteilen: Analyse des Einflusses des Mapping-Ansatzes auf die Vorhersagegüte
Numerical edge failure prediction of stamped parts: Analysis of the influence of the mapping approach on the prediction quality

Bode, Lorenz
Tekkaya, A. E.; Schowtjak, A.
Analyse und Entwicklung verschiedener Strategien für die Bestimmung von Bruchortskurven
Analysis and development of various strategies for the determination of fracture loci

Dayasagar, Jaswanth
Tekkaya, A. E.; Löbbe, C.
Simulationsgestützte Analyse der Kompensation von Einfallstellen in Blechformteilen der Karosserie-Außenhaut
Simulation based analysis of compensation of surface lows in sheet metal parts

Detzel, Andreas
Tekkaya, A. E.; Wernicke, S.
Untersuchung elektro-plastischer Effekte bei der Herstellung von Funktionsbauteilen durch inkrementelle Blechmassivumformung
Investigation on electro-plastic effects in incremental sheet-bulk metal forming of functional elements

Dyballa, Jan
Tekkaya, A. E.; Rosenthal, S.
Topologieoptimierung metallischer Sandwichbauteile für die Biegeumformung
Optimization of the topology of metallic sandwich sheets for bending processes

Gitschel, Robin
Tekkaya, A. E.; Schowtjak, A.
Analyse unterschiedlicher Ansätze für die Identifikation von Schädigungs- und Plastizitätsparametern
Analysis of different approaches for the identification of damage and plasticity related parameters

1 Originaltitel ist fett gedruckt.
2 Original title written in bold.

Jaiswal, Sumant Kumar
Tekkaya, A. E.; Traphöner, H.
Bewertung von Methoden zur Materialcharakterisierung und Materialmodellierung für die numerische Simulation des Stanznietens
Evaluation of material characterization methods and material models for the numerical simulation of self-piercing riveting

Kotzyba, Patrick
Tekkaya, A. E.; Gebhard, J.
Untersuchung des kontinuierlichen Strangpressens unter Anwendung der Ähnlichkeitstheorie
Investigation of continuous extrusion using the principle of similitude

Krieger, Julia
Tekkaya, A. E.; Tebaay, L.
Einfluss der Oberflächentopologie bei einer Prozesskombination aus inkrementeller Blechumformung und Laserpulverauftragsschweißen
Influence of the surface topology of a process combination of incremental sheet forming and laser powder deposition

Kuruva, Srinath
Tekkaya, A. E.; Schmitz, F.
Numerische Analyse und Kompensation des Einflusses des elastischen Verhaltens von Stanzmaschinen auf Blechbauteile
Numerical analysis and compensation of the influence of elastic behavior of stamping machines on sheet metal components

Omer, Mohammed
Tekkaya, A. E.; Kamaliev, M.
Auslegung und Analyse von Kühlkanälen für ein rapides Warmumformwerkzeug
Design and analysis of cooling channels for a rapid hot forging die

Sarafraz, Yashar
Tekkaya, A. E.; Kolpak, F.
Einfluss der Prozessparameter auf die Längspressnahtqualität beim Strangpressen
Influence of process parameters on longitudinal weld seam quality in hot extrusion

Sariyildiz, Ömer
Tekkaya, A. E.; Weber, F.
Numerische und analytische Untersuchung der Fügestellenauslegung beim Außenhochdruckfügen
Numerical and analytical investigation of the joining zone design for joining with outer pressurization

Sarker, Manabendra
Tekkaya, A. E.; Komodromos, A.
Analyse des Einflusses der Düsengeometrie und wechselwirkender Prozessparameter auf das Linearwickeln
Analysis of the influence of the nozzle geometry and interacting parameters on the coil winding method

Schwendemann, Nico (2018)
Tekkaya, A. E.; Kamaliev, M.
Untersuchung der diffusiblen Wasserstoffgrenzen von neuen höchstfesten Stählen im Presshärteprozess
Investigation of the diffusible hydrogen limits of new high-strength steels in the press hardening process

Triebert, Nicolas
Tekkaya, A. E.; Meya, R.
Analyse der Leistungsfähigkeit gebogener Bauteile
Analysis of the performance of bent products

Wahab, Abdul
Tekkaya, A. E.; Schowtjak, A.
Experimentelle und numerische Versagensanalyse von AHSS-Blechen mit verschiedenen Plastizitäts- und Schädigungsmodellen
Experimental and simulative failure evaluation of advanced high-strength steels with different plasticity and failure models

Wapande, Sadam Hamis
Tekkaya, A. E.; Dardaei, H.
Umformbarkeitsanalyse von 3105-Aluminium-Verbundplatten mittels Multi-Point-Forming-Prozesses
Formability analysis of 3105 aluminium composite panels by means of the multi-point forming process

Yasar, Yavuz
Tekkaya, A. E.; Martschin, J.
Bruchaufspaltung von mikrolegierten Feinkornstählen beim Lochstanzversuch
Separations in micro alloyed steel during the hole punching test

Zahner-Gothen, Marcel
Tekkaya, A. E.; Tebaay, L.
Charakterisierung der mechanischen Verbundeigenschaften von Hybridbauteilen, welche mittels inkrementeller Blechumformung und additiver Fertigung hergestellt werden
Characterization of mechanical compound properties of hybrid parts made by incremental sheet forming and additive manufacturing

Abgeschlossene Bachelorarbeiten | Completed Bachelor of Science Theses

Adams, Tom
Tekkaya, A. E.; Rosenthal, S.
Analyse des Laserpulverauftragsschweißens als Fertigungsprozess zum Aufbau hybrider Blechumformwerkzeuge
Investigation of laser powder deposition for the manufacturing of hybrid sheet metal forming tools

Banimb Matoun, Christian
Tekkaya, A. E.; Lueg-Althoff, J.
Analyse und Optimierung des Produktionsprozesses von Diesel-Hochdruckleistungen
Analysis and optimization of the production process of diesel high-pressure lines

Bechler, Jan
Tekkaya, A. E.; Rosenthal, S.
Inverse Parameteridentifikation additiv hergestellter Tragwerksstrukturen
Inverse parameter identification of additively manufactured cellular structures

Bosse, Gerrit
Tekkaya, A. E.; Löbbe, C.
Entwicklung eines Dorn-Systems für das Profilbiegen mit Druckspannungsüberlagerung
Development of a mandrel system for profile bending with stress superposition

Bürstner, Fabio Maximilian
Tekkaya, A. E.; Traphöner, H.
Analyse der Einflussfaktoren bei der Ermittlung von Werkstoffeigenschaften unter Wechselbiegebelastung
Analysis of influencing factors during the determination of material properties under cyclic bending load

Dick, Christian
Tekkaya, A. E.; Lueg-Althoff, J.
Untersuchung des Aufprall-Lichtblitzes bei der Verschweißung zweier metallischer Bauteile mittels elektromagnetischer Umformung
Investigation of the impact flash during magnetic pulse welding of two metal parts

Dzikus, Pascal
Weichert, F. (Fak. Informatik); Tekkaya, A. E.
Optische Identifikation von Bewegungsfeldern für Formveränderungen
Optical identification of motion fields for shape changes

Efendioglu, Emin
Tekkaya, A. E.; Napierala, O.
Experimentelle Untersuchung des Tiefzieh-Verbundfließpressens mit Spänekern
Experimental investigation of draw-forging with chip-based cores

Guo, Yu
Tekkaya, A. E.; Traphöner, H.
Analyse des ebenen Torsionsversuchs mit überlagertem axialem Zug
Analysis of the in-plane torsion test with superposed axial tension

Hmeidan, Mohamed
Tekkaya, A. E.; Martschin, J.
Numerische Untersuchung des Profilbiegens mit Druckspannungsüberlagerung durch Walzen
Numerical investigation of profile bending with stress superposition by rolling

Kramer, Christian
Tekkaya, A. E.; Weber, F.
Analyse eines teilbaren Dichtungskonzepts beim Außenhochdruckfügen
Analysis of a separable sealing concept for joining by outer pressurization

Möseler, Maximilian
Tekkaya, A. E.; Gallus, S.
Zusammenhang zwischen Schweißnahtorientierung und Bauteilverzug durch Wärmeeintrag bei längsgeschweißten Rohren
Correlation between weld seam orientation and component distortion due to heat input in longitudinally welded tubes

Reihani Masouleh, Alborz
Tekkaya, A. E.; Tebaay, L.
Optimierung des Laserpulverauftragsschweißens durch Variation der Bahnstrategie
Optimization of laser powder deposition welding by varying the tool path strategy

Rethmann, Philipp
Tekkaya, A. E.; Löbbe, C.
Erweiterte Verfahrensgrenzen beim kinematischen Profilbiegen mittels gradierter Querschnittstemperierung
Extended process limits for kinematic profile bending by graded cross-section temperature control

Schreiner, Christian
Tekkaya, A. E.; Maaß, F.
Analyse des Einflusses nachgelagerter Schneidprozesse auf den Eigenspannungszustand inkrementell umgeformter Blechbauteile
Analysis of the influence of subsequent cutting operations on the residual stress state of incrementally formed parts

Schulz, Oliver
Tekkaya, A. E.; Traphöner, H.
Entwicklung und Analyse neuer Nutformen im ebenen Torsionsversuch
Development and analysis of new groove shapes for the in-plane torsion test

Trautwein, Georg
Tekkaya, A. E.; Gallus, S.
Entwicklung und Validierung eines Biegewerkzeugs zum Biegen doppelwandiger Rohrleitungen
Development and validation of a bending tool for bending double-walled tubes

Abgeschlossene Projektarbeiten | Completed Project Theses

Altinsoy, Emre; Karaca, Fatih
Tekkaya, A. E.; Schmitz, F.
Vergleich von konventionellem und adiabatischem Scherschneiden durch analytische und numerische Ansätze
Comparison of conventional and adiabatic blanking by analytical and numerical approaches

Araghchi, Pouria
Tekkaya, A. E.; Grodotzki, J.; Weber, F.
Experimentelle Untersuchung der Plastizität in Aluminium-Einkristallen
Experimental investigation of plasticity in aluminum single crystals

Banimb Matoun, Christian
Tekkaya, A. E.; Lueg-Althoff, J.
Konstruktive Gestaltung einer Prüfvorrichtung für formschlüssig gefügte Bleche
Design of a testing device for sheets joined by form-fit

Bhattarai, Yogesh
Tekkaya, A. E.; Upadhya, S.
Machbarkeit der Vorhersage beim Streckbiegen mithilfe der konkaven Seitenregel
Stretch-bending forming limit prediction with the concave side rule

Blickling, Philipp; Schulz, Oliver
Tekkaya, A. E.; Traphöner, H.; Gutknecht, F.
Analyse und Bewertung unterschiedlicher Verfahren zur Fertigung von Nutproben für den ebenen Torsionsversuch
Analysis and evaluation of different methods for the manufacturing of grooved specimens for the in-plane torsion test

Bürstner, Fabio Maximilian
Tekkaya, A. E.; Traphöner, H.; Dardaei, H.
Entwicklung einer Erweiterung des ebenen Torsionsversuches für Temperaturen bis 1100 °C
Development of an extension of the in-plane torsion test for temperatures up to 1100 °C

Deiters, Alexander; Windmann, Dominik
Tekkaya, A. E.; Sieczkarek, P.; Gies, S.
Werkstoffcharakterisierung von Edelstahlfolien für den Einsatz bei der inkrementellen Blechumformung
Material characterization of stainless steel foils for the application in incremental sheet metal forming processes

Donfack Mezatio, Bertrand
Tekkaya, A. E.; Lueg-Althoff, J.
Methoden zur Prüfung der Kantenrissempfindlichkeit
Testing methods for edge cracking evaluation

Dukat, Paul
Tekkaya, A. E.; Kamaliev, M.; Komodromos, A.
Entwicklung und Erprobung eines Versuchsstandes zur experimentellen Ermittlung des Werkstoffverhaltens von plattiertem Stahl beim Warmbiegen
Development and testing of an experimental set-up for the investigation of the material behavior of clad steel during hot bending

Esken, Lukas
Tekkaya, A. E.; Grodotzki, J.; Weber, F.
Eine iterative Identifikation rheologischer Parameter sowie des Wärmeübergangskoeffizienten beim Hochtemperatur-Schmieden
An iterative identification of rheological parameters and heat transfer coefficients in hot forging

Gerlach, Jan
Tekkaya, A. E.; Schowtjak, A.; Gitschel, R.
Einfluss der Probengeometrie auf die Parameteridentifikation von Schädigungsmodellen
Effect of the specimen geometry on the parameter identification of ductile damage models

Gitschel, Robin
Tekkaya, A. E.; Schowtjak, A.; Clausmeyer, T.
Parameteridentifikation auf Basis von Daten der digitalen Bildkorrelation
Digital image correlation-aided parameter identification

Hartwich, Patrick
Tekkaya, A. E.; Meya, R.; Ortelt, T.
Entwicklung eines Programmes zur Analyse des Spannungszustandes beim Biegen mit radialer Spannungsüberlagerung
Development of a program for the analysis of the stress state for bending with radial stress superposition

Hater, Sebastian
Tekkaya, A. E.; Komodromos, A.; Rosenthal, S.
Experimentelle Untersuchung des Drahtbiegens mit überlagerter Zugkraft auf Basis des Linearwickelns rechteckiger Spulenkörper
Experimental analysis of wire bending with a superposed tensile force on the basis of the linear winding of rectangular coil bobbins

Kaya, Deniz
Tekkaya, A. E.; Clausmeyer, T.; Gutknecht, F.
Gestaltvorhersage nicht-runder Rohre nach dem Aufweiten
Shape prediction of non-round tubes after expansion

Kocher, Isabelle
Tekkaya, A. E.; Grodotzki, J.; Rosenthal, S.
Reduktion von Versuchsumfängen und Verbesserung der Ergebnisse mittels Versuchsplanung
On the reduction of the number of experiments and the improvement of results using DOE

Kortum, Nico
Tekkaya, A. E.; Wernicke, S.; Traphöner, H.
Verfestigungsverhalten des Tiefziehstahls DC04 im ebenen Torsionsversuch unter alternierender Belastung
Strain hardening behavior of DC04 in the in-plane torsion test using alternating loads

Kumar, Haresh
Tekkaya, A. E.; Löbbe, C.; Meya, R.
Numerische Untersuchung der überlagerten Oszillationen beim inkrementellen Profilumformen
Numerical investigation of superposed oscillations in incremental profile forming

Kuruva, Srinath
Tekkaya, A. E.; Löbbe, C.; Meya, R.
Strategie zur Rohrverjüngung durch Crimpen und Formen von ovalen Rohren mittels inkrementeller Profilumformung
Strategy for tube reduction using rotary swaging and preparation of oval tubes using incremental profile forming

Noe, Daniel
Tekkaya, A. E.; Kamaliev, M.; Martschin, J.
Implementierung und Durchführung von Warm-Reibversuchen durch konstruktive Änderungen der Streifenziehmaschine
Implementation and conduction of hot friction drawing tests by design adaption of the strip drawing machine

Rethmann, Philipp; Bosse, Gerrit
Tekkaya, A. E.; Meya, R.; Martschin, J.
Entwicklung einer Vorrichtung zum Trennen von Biegeproben durch Sprödbruch
Development of a device for separating bending samples by brittle fracture

Ruzwan, Yacob
Tekkaya, A. E.; Lueg-Althoff, J.; Rosenthal, S.
Einfluss der Aufbaurichtung auf die mechanischen Eigenschaften mittels SLM gefertigter Proben des austenitischen Edelstahls 316L
Influence of the building direction during SLM on the mechanical properties of specimens made of austenitic stainless steel 316L

Schreiber, Frerk
Tekkaya, A. E.; Rosenthal, S.
Erstellung und Validierung einer Simulation für die Umformung additiv gefertigter Bleche
Development and validation of a simulation for forming of additively manufactured sheets

Stennei, Markus
Tekkaya, A. E.; Dardaei, H.
Analytische Betrachtungsweise des Spritzdrucks beim Hinterspritzen von Stahl-Kunststoffhybriden
Analytical approach of the injection pressure in the back injection molding of steel plastic hybrids

Szajna, Jan Philip
Tekkaya, A. E.; Wernicke, S.; Tebaay, L.
Weiterentwicklung eines variablen Kammerungskonzeptes für die inkrementelle Blechmassivumformung
Further development of a variable chambering concept for incremental sheet-bulk metal forming

Tariq, Faizan
Tekkaya, A. E.; Gutknecht, F.; Clausmeyer, T.
Erstellung und Validierung eines Simulationsmodells für Bauteil-Crash-Versuche
Creation and validation of a simulation model of a crash test rig for component testing

Tufanyan, Tigran
Tekkaya, A. E.; Rickmer, M.; Ortelt, T.
Entwicklung eines Programmes zur Analyse des Spannungszustandes beim Biegen mit radialer Spannungsüberlagerung
Development of a program for the analysis of the stress state for bending with radial stress superposition

Wahab, Abdul
Tekkaya, A. E.; Napierala, O.; Gebhard, J.
Numerische Abbildung des Tiefzieh-Verbundfließpressens mit Spänen
Combined deep drawing and cold forging process for recycling of aluminum chips

Yasar, Yavuz
Tekkaya, A. E.; Napierala, O.; Gebhard, J.
Zweistufiges Tiefzieh-Verbundfließpressen – Auslegung, Konstruktion und Durchführung
Extended draw-forging by redrawing – process- and tool design and experiments

Ausgewählte Veröffentlichungen und Vorträge | Selected Publications and Lectures

08

Zeitschriftenbeiträge | For SCI-Journals (Peer Reviewed)

Bellmann, J., Lueg-Althoff, J., Schulze, S., Hahn, M., Gies, S., Beyer, E., Tekkaya, A. E., 2019. Effect of the wall thickness on the forming behavior and welding result during magnetic pulse welding. Materialwissenschaft und Werkstofftechnik 50, pp. 883–892.

Bellmann, J., Lueg-Althoff, J., Schulze, S., Hahn, M., Gies, S., Beyer, E., Tekkaya, A. E., 2019. Thermal Effects in Dissimilar Magnetic Pulse Welding. Metals 9 (3), DOI: 10.3390/met9030348.

Dahnke, C., Pottmeyer, F., Pinter, P., Weidenmann, K. A., Tekkaya, A. E., 2019. Influence of SMA-induced stress on shape memory alloy metal matrix composites manufactured by continuous composite extrusion. Smart Materials and Structures 28 (8), DOI: 10.1088/1361-665X/ab2d6a.

Dahnke, C., Reeb, A., Pottmeyer, F., Weidenmann, K. A., Tekkaya, A. E., 2019. Thermomechanical behavior of shape memory alloy metal matrix composite actuator manufactured by composite extrusion. Smart Materials and Structures 28 (5), DOI: 10.1088/1361-665X/ab0ef5.

Grzancic, G., Löbbe, C., Ben Khalifa, N., Tekkaya, A. E., 2019. Analytical prediction of wall thickness reduction and forming forces during the radial indentation process in Incremental Profile Forming. Journal of Material Processing Technology 267, DOI: 10.1016/j.jmatprotec.2018.12.003.

Hering, O., Dunlap, A., Aretz, A., Schwedt, A., Tekkaya, A. E., 2019. Characterization of damage in forward rod extruded parts. International Journal of Material Forming, DOI: 10.1007/s12289-019-01525-z.

Hering, O., Kolpak, F., Tekkaya, A. E., 2019. Flow curves up to high strains considering load reversal and damage. International Journal of Material Forming, DOI: 10.1007/s12289-018-01466-z.

Hou, Y., Min, J., Guo, N., Lin, J., Carsleyb, J. E., Stoughton, T. B., Traphöner, H., Clausmeyer, T., Tekkaya, A. E., 2019. Investigation of evolving yield surfaces of dual-phase steels. Journal of Materials Processing Technology, DOI: 10.1016/j.jmatprotec.2019.116314.

Kolpak, F., Schulze, A., Dahnke, C., Tekkaya, A. E., 2019. Predicting weld-quality in direct hot extrusion of aluminium chips. Journal of Materials Processing Technology 274, DOI: 10.1016/j.jmatprotec.2019.116294.

Meya, R., Kusche, C. F., Löbbe, C., Al-Samman, T., Korte-Kerzel, S., Tekkaya, A. E., 2019. Global and High-Resolution Damage Quantification in Dual-Phase Steel Bending Samples with Varying Stress States. Metals 9 (3), DOI: 10.3390/met9030319.

Meya, R., Löbbe, C., Tekkaya, A. E., 2019. Stress State Analysis of Radial Stress Superposed Bending. International Journal of Precision Engineering and Manufacturing 20 (1), DOI: 10.1007/s12541-019-00040-0.

Meya, R., Löbbe, C., Tekkaya, A. E., 2019. Stress State Control by a Novel Bending Process and its Effect on Damage and Product Performance. Journal of Manufacturing Science and Engineering 141 (10), DOI: 10.1115/1.4044394.

Napierala, O., Dahnke, C., Tekkaya, A. E., 2019. Simultaneous deep drawing and cold forging of multi-material components: Draw-forging. CIRP Annals – Manufacturing Technology, DOI: 10.1016/j.cirp.2019.03.001.

Nazari, E., Staupendahl, D., Löbbe, C., Tekkaya, A. E., 2019. Bending moment in incremental tube forming. International Journal of Material Forming 12 (1), pp. 113-122.

Ossenkemper, S., Dahnke, C., Tekkaya, A. E., 2019. Analytical and experimental bond strength investigation of cold forged composite shafts. Journal of Materials Processing Technology 264, DOI: 10.1016/j.jmatprotec.2018.09.008.

Rosenthal, S., Platt, S., Hölker-Jäger, R., Gies, S., Kleszczynski, S., Tekkaya, A. E., Witt, G., 2019. Forming properties of additively manufactured monolithic Hastelloy X sheets. Materials Science and Engineering: A 753, DOI: h10.1016/j.msea.2019.03.035.

Weber, F., Müller, M., Haupt, P., Gies, S., Hahn, M., Tekkaya, A. E., 2019. Analytical process design for interference-fit joining of rectangular profiles. Journal of Materials Processing Technology 276, DOI: 10.1016/j.jmatprotec.2019.116391.

Wernicke, S., Sieczkarek, P., Gies, S., Tekkaya, A. E., 2019. Properties of Components with Incrementally Formed Gears. Metals 9 (5), DOI: 10.3390/met9050515.

Beiträge in Konferenzbänden & weiteren Zeitschriften | Publications in Proceedings and further Journals

Bellmann, J., Lueg-Althoff, J., Schulze, S., Hahn, M., Gies, S., Beyer, E., Tekkaya, A. E., 2019. Magnetic pulse welding of tubular parts. In: AIP Conference Proceedings 2113, Proceedings of the 22^{nd} International ESAFORM Conference on Material Forming, Vitoria-Gasteiz, Spain, DOI: 10.1063/1.5112579.

Bellmann, J., Schettler, S., Dittrich, S., Lueg-Althoff, J., Schulze, S., Hahn, M., Beyer, E., Tekkaya, A. E., 2019. Experimental study on the magnetic pulse welding process of large aluminum tubes on steel rods. Materials Science and Engineering 480, DOI: 10.1088/1757-899X/480/1/012033.

Bellmann, J., Ueberschaer, F., Lueg-Althoff, J., Schulze, S., Hahn, M., Beyer, E., Tekkaya, A. E., 2019. Effect of the Forming Behavior on the Impact Flash during Magnetic Pulse Welding of Tubes. In: Proceedings of NUMIFORM 2019: The 13^{th} International Conference on Numerical Methods in Industrial Forming Processes, New Hampshire, USA, pp. 651-654.

Clausmeyer, T., Nürnberger, F., Gutknecht, F., Isik, K., Besserer, H., Gerstein, G., Wernicke, S., Schulte, R., Tekkaya, A. E., Merklein, M., Maier, H., 2019. Analyse und Modellierung von Schädigung und Versagen in der Blechmassivumformung. 4. Workshop Blechmassivumformung, Erlangen, Germany, pp. 33-60.

Coppieters, S., Jäckel, M., Miyake, N., Kraus, C., Traphöner, H., Kuwabara, T., Tekkaya, A. E., 2019. Large Strain Flow Curve Identification for sheet metal: Process-Informed Method Selection. In: Proceedings of 12^{th} Forming Technology Forum, Herrsching am Ammersee, Germany, (Digital).

Dardaei Joghan, H., Hahn, M., Traphöner, H., Tekkaya, A. E., 2019. Influence of the preheating strategy on the deep drawing of extruded magnesium alloy ME20 sheets. In: Proceedings of the 38^{th} International Deep Drawing Research Group (IDDRG) Annual Conference, Enschede, The Netherlands, (Digital).

Dardaei Joghan, H., Izadyar, S. A., Hahn, M., Tekkaya, A. E., 2019. Effect of the unbending process on mechanical properties before and after flattening of extruded open tubes of magnesium alloy ME20. In: AIP Conference Proceedings 2113, Proceedings of the 22^{nd} International ESAFORM Conference on Material Forming Vitoria-Gasteiz, Spain, DOI: 10.1063/1.5112707.

Gutknecht, F., Clausmeyer, T., 2019. Analysis of strain-path change indicator for application in sheet-bulk metal forming. In: Proceedings of 12th Forming Technology Forum, 19.-20.09.2019, Herrsching am Ammersee, Germany, (Digital).

Gutknecht, F., Vogel, M., Schulte, R., Merklein, M., Rosenbusch, D., Koch, S., Hübner, S., Behrens, B., Tekkaya, A. E., Clausmeyer, T., 2019. Comparison of strain-path indicators for analysis of processes in sheet-bulk metal forming. In: Proceedings of NUMIFORM 2019: The 13th International Conference on Numerical Methods in Industrial Forming Processes, New Hampshire, USA, pp. 123-126.

Hahn, M., Goyal, S., Gies, S., Tekkaya, A. E., 2019. Numerical Modeling of Energy Deposition for Vaporizing foil actuator Forming. In: Proceedings of NUMIFORM 2019: The 13th International Conference on Numerical Methods in Industrial Forming Processes, New Hampshire, USA, pp. 667-670.

Hering, O., Kolpak, F., Dahnke, C., Tekkaya, A. E., 2019. High Strain Flow Curves by Mechanical Tests on Specimens Pre-strained by Forward Rod Extrusion. In: Proceedings of 52nd ICFG Plenary Meeting 2019, Donostia-San Sebastián, Spain, pp. 149-156.

Hoffmann, E., Kamaliev, M., Löbbe, C., Tekkaya, A. E., 2019. Enhanced process limits in the granular media-based tube forming through axial feeding. In: 7th International Conference on Hot Sheet Metal Forming of High-Performance Steel CHS, Luleå, Sweden, pp. 95-102.

Kolpak, F., Hering, O., Dahnke, C., Tekkaya, A. E., 2019. Producing Hollow Shafts by Composite Extrusion Utilizing Granular Cores. In: Proceedings of 52nd ICFG Plenary Meeting 2019, Donostia-San Sebastián, Spain, pp. 225-232.

Kolpak, F., Dahnke, C., Tekkaya, A. E., 2019. Forming-induced anisotropy of product properties in cold extrusion. In: Proceedings of the METEC and 4th European Steel Technology and Application Days, Düsseldorf, Germany, (Digital).

Lueg-Althoff, J., Bellmann, J., Hahn, M., Schulze, S., Tekkaya, A. E., Beyer, E., 2019. Joining Dissimilar Thin-Walled Tubes by Magnetic Pulse Welding. In: Book of abstracts of 1st International Conference on Advanced Joining Processes, Ponta Delgada, Azores, p. 54.

Lueg-Althoff, J., Beu, M.-A., Güzel, A., Rohr, T., Hahn, M., 2019. Experimental and numerical investigations of joining by electromagnetic forming for aeronautical applications. In: AIP Conference Proceedings 2113, Proceedings of the 22nd International ESAFORM Conference on Material Forming, Vitoria-Gasteiz, Spain, DOI: 10.1063/1.5112576.

Maaß. F., Dobecki, M., Hahn, M., Reimers, W., Tekkaya, A. E., 2019. Setting Component Properties in Incremental Forming. In: Proceedings of MS&T 2019, Portland, USA, pp. 1176-1182.

Maaß, F., Hahn, M., Dobecki, M., Thannhäuser, E., Tekkaya, A. E., Reimers, W., 2019. Influence of tool path strategies on the residual stress development in single point incremental forming. Procedia Manufacturing 29, pp. 53-59.

Maaß, F., Hahn, M., Tekkaya, A. E., Dobecki, M., Poeche, A., Brommelhoff, K., Reimers, W., 2019. Forming mechanisms-related residual stress development in single point incremental forming. Production Engineering – Research and Development 13 (2), DOI: 10.1007/s11740-018-0867-3.

Martschin, J., Meya, R., Löbbe, C., Tekkaya, A. E., 2019. Novel roll stand for flexible profile bending. In: Proceedings of the 38th International Deep Drawing Research Group (IDDRG) Annual Conference, Enschede, The Netherlands, (Digital).

Mennecart, T., Gies, S., Ben Khalifa, N., Tekkaya, A. E., 2019. Analysis of the Influence of Fibers on the Formability of Metal Blanks in Manufacturing Processes for Fiber Metal Laminates. Journal of Manufacturing and Materials Processing 3 (1), DOI: 10.3390/jmmp3010002.

Münstermann, S., Sparrer, Y., Yao, Y., Lian, J., Meya, R., Clausmeyer, T., Tekkaya, A. E., 2019. Effect of plastic strain and ductile damage on elastic modulus of multiphase steel and its impact on springback prediction. In: AIP Conference Proceedings 2113, Proceedings of the 22nd International ESAFORM Conference on Material Forming, Vitoria-Gasteiz, Spain, DOI: 10.1063/1.5112739.

Rosenthal, S., Hahn, M., Tekkaya, A. E, 2019. Simulation approach for three-point plastic bending of additively manufactured Hastelloy X sheets. Procedia Manufacturing 34, pp. 475–481, DOI: 10.1016/j.promfg.2019.06.201.

Schowtjak, A., Kusche, C., Meya, R., Al-Samman, T., Korte-Kerzel, S., Tekkaya, A. E., Clausmeyer, T., 2019. Prediction of void evolution in sheet bending based on statistically representative microstructural data for the Gurson-Tvergaard-Needleman model. In: Proceedings of NUMIFORM 2019: The 13th International Conference on Numerical Methods in Industrial Forming Processes, New Hampshire, USA, pp. 311-314.

Selvaggio, A., Upadhya, S., Grodotzki, J., Tekkaya, A. E., 2019. Development of a Remote Compression Test Lab for Engineering Education. In: Proceedings of the 16th International Conference on Remote Engineering and Virtual Instrumentation (REV), Bengaluru, India, pp. 496-505.

Tebaay, L. M., Sieczkarek, P., Hahn, M., Gies, S., Tekkaya, A. E., 2019. Development of the Incremental Micro-Forming Process for small batch production of metallic bipolar plates. In: Ideen Form geben. 33. ASK Umformtechnik, Aachen, Germany, pp. 347-357.

Tekkaya, A. E., Traphöner, H., Hering, O., Kolpak, F., Gutknecht, F., Schowtjak, A., 2019. Über die klassische Werkstoffprüfung hinaus – Werkstoffeigenschaften für die moderne Umformtechnik. In: DGM dIALOG – Materialwissenschaften und Werkstofftechnik – Werkstoffprüfung 2, pp.26-31.

Ünsal, I., Hirtler, M., Svirodov, A., Bambach, M., Hama-Saleh, R., Weisheit, A., Schleifenbaum, J. H., Kamaliev, M., Tekkaya, A. E., 2019. Investigation of martensite-transformation and forming properties of additively reinforced 22MnB5 sheet metals. In: AIP Conference Proceedings 2113, Proceedings of the 22nd International ESAFORM Conference on Material Forming, Vitoria-Gasteiz, Spain, DOI: 10.1063/1.5112735.

Upadhya, S., Selvaggio, A., Ortelt, T. R., Grodotzki, J., Tekkaya, A. E., 2019. Development of a Remote Tube Bending Lab to Illustrate Springback and Determine Process Limits. In: Proceedings of the 16th International Conference on Remote Engineering and Virtual Instrumentation (REV), Bengaluru, India, pp. 95-106.

Weber, F., Hahn, M., Tekkaya, A. E., 2019. Joining by die-less hydroforming with outer pressurization. In: Book of abstracts of 1st International Conference on Advanced Joining Processes, Ponta Delgada, Azores, pp. 56.

Wernicke, S., Gies, S., Tekkaya, A. E., 2019. Manufacturing of hybrid gears by incremental sheet-bulk metal forming. Procedia Manufacturing 27, pp. 152–157, DOI: 10.1016/j.promfg.2018.12.058.

Wernicke, S., Sieczkarek, P., Tekkaya, A. E., 2019. Auch inkrementell rechnet sich die Blechmassivumformung. Maschinenmarkt 1, pp. 22-23.

Keynote-Vorträge | Keynote Presentations

Tekkaya, A. E., Kamaliev, M., 2019. Umformen von Leichtbaukomponenten. Härtereikongress 2019, 22.-24.10.2019, Köln, Germany.

Tekkaya, A. E., Schmitz, F., Hering, O., Kolpak, F., 2019. Component Performance after Forming. Transvalor International Simulation Days 2019, 15.-17.10.2019, Sophia-Antipolis, France.

Traphöner, H., Clausmeyer, T., Tekkaya, A. E., 2019. Challenges in material characterization with the in-plane torsion test. 12^{th} Forming Technology Forum, 19.-20.09.2019, Herrsching am Ammersee, Germany.

Vorträge | Presentations

Dahnke, C., Ossenkemper, S., Napierala, O., Hering, O., Tekkaya, A. E., 2019. Innovative Umformprozesse zur Fertigung von Leichtbauteilen. 6. Technologietag Hybrider Leichtbau, 20.-21.05.2019, Stuttgart, Germany.

Förster, T., Gebhard, J., Löbbe, C., 2019. Biegen von CNC-gestanzten Profilen mit engen Radien – Ergebnisse industrienaher Forschung. Biegen in Siegen, 06.-07.03.2019, Siegen, Germany.

Kolpak, F., Dahnke, C., Tekkaya, A. E., 2019. Forming-induced anisotropy of product properties in cold extrusion. METEC & 4^{th} ESTAD, 24.-28.06.2019, Düsseldorf, Germany.

Lueg-Althoff, J., Clausmeyer, T., Schmitz, F., Tekkaya, A. E., 2019. Processing of components from high strength steels within the ReCIMP project. Materials Chain Early Career Researchers' Forum, 16.09.2019, Dortmund, Germany.

Maaß, F., Hahn, M., Dobecki, M., Reimers, W., Tekkaya, A. E., 2019. Single Point Incremental Forming: Relation between Forming Mechanisms and Residual Stresses for Different Path Strategies and Geometries. 15th International Conference on Computational Plasticity, 03.-05.09.2019, Barcelona, Spain.

Tekkaya, A. E., 2019. Prof. Lange's Impact in Metal Forming. Ehrenkolloquium anlässlich des 100. Geburtstags von Prof. Kurt Lange, 13.12.2019, Stuttgart, Germany.

Tekkaya, A. E., Traphöner, H., Clausmeyer, T., 2019. Sheet metal characterization with the in-plane torsion test. ZwickRoell Academia Day, 14.06.2019, Shanghai, China.

Traphöner, H., Clausmeyer, T., Tekkaya, A. E., 2019. Charakterisierung von Blechwerkstoffen im ebenen Torsionsversuch. 28th testXpo, 14.-17.10.2019, Ulm, Germany.

Traphöner, H., Clausmeyer, T., Tekkaya, A. E., 2019. Materialcharakterisierung für umformtechnische Anwendungen. ZwickRoell Forum, 28.03.2019, Dortmund, Germany.

Traphöner, H., Tekkaya, A. E., Rosenschon, M., Merklein, M., 2019. Charakterisierung und Modellierung des zyklischen Verfestigungsverhaltens zur Verbesserung der numerischen Vorhersage von Blechumformprozessen. EFB Kolloquium, 02.-03.04.2019, Bad Boll, Germany.

Mitarbeiter | Staff

09

Professoren | Professors

Prof. Dr.-Ing. Dr. h.c. Matthias Kleiner
(beurlaubt)
0231 755 2680
matthias.kleiner@udo.edu

Prof. Dr.-Ing. Dr.-Ing. E.h. A. Erman Tekkaya
0231 755 2681
erman.tekkaya@iul.tu-dortmund.de

Sekretariat | Office

Dipl.-Dolm. Jeanette Brandt
0231 755 2660
jeanette.brandt@iul.tu-dortmund.de

Nina Hänisch M. A.
0231 755 5846
nina.haenisch@iul.tu-dortmund.de

Oberingenieur | Chief Engineer

Dr.-Ing. Dipl.-Wirt.-Ing. Soeren Gies
Oberingenieur
0231 755 5238
soeren.gies@iul.tu-dortmund.de

Abteilungsleiter | Heads of Department

Dr.-Ing. Till Clausmeyer
Abteilungsleiter Angewandte Mechanik in der Umformtechnik
0231 755 8429
till.clausmeyer@iul.tu-dortmund.de

Marlon Hahn M. Sc.
Abteilungsleiter Sonderverfahren
0231 755 8415
marlon.hahn@iul.tu-dortmund.de

Oliver Hering M. Sc.
Abteilungsleiter Massivumformung
0231 755 8432
oliver.hering@iul.tu-dortmund.de

Dr.-Ing. Dipl.-Wirt.-Ing. Soeren Gies
Abteilungsleiter Projektierung
0231 755 5238
soeren.gies@iul.tu-dortmund.de

Dr.-Ing. Christian Löbbe
Abteilungsleiter Profil- und Blechumformung
0231 755 8431
christian.loebbe@iul.tu-dortmund.de

Abteilung Massivumformung | Bulk Metal Forming

Oliver Hering M. Sc.
Abteilungsleiter Massivumformung
0231 755 8432
oliver.hering@iul.tu-dortmund.de

Johannes Gebhard M. Sc.
0231 755 4751
johannes.gebhard@iul.tu-dortmund.de

Robin Gitschel M. Sc.
0231 755 8453
robin.gitschel@iul.tu-dortmund.de

Felix Kolpak M. Sc.
0231 755 8433
felix.kolpak@iul.tu-dortmund.de

Patrick Kotzyba M. Sc.
0231 755 2630
patrick.kotzyba@iul.tu-dortmund.de

André Schulze M. Sc.
0231 755 2654
andre.schulze@iul.tu-dortmund.de

Abteilung Angewandte Mechanik in der Umformtechnik | Applied Mechanics in Forming Technologies

Dr.-Ing. Till Clausmeyer
Abteilungsleiter Angewandte Mechanik
in der Umformtechnik
0231 755 8429
till.clausmeyer@iul.tu-dortmund.de

Joshua V. Grodotzki M. Sc.
0231 755 7852
joshua.grodotzki@iul.tu-dortmund.de

Florian Gutknecht M. Sc.
0231 755 8483
florian.gutknecht@iul.tu-dortmund.de

Fabian Schmitz M. Sc.
0231 755 8498
fabian.schmitz@iul.tu-dortmund.de

Alexander Schowtjak M. Sc.
0231 755 8476
alexander.schowtjak@iul.tu-dortmund.de

Heinrich Traphöner M. Sc.
0231 755 8439
heinrich.traphoener@iul.tu-dortmund.de

Abteilung Profil- und Blechumformung | Profile- and Sheet Metal Forming

Dr.-Ing. Christian Löbbe
Abteilungsleiter Profil- und Blechumformung
0231 755 8431
christian.loebbe@iul.tu-dortmund.de

Stefan Gallus M. Sc.
0231 755 2402
stefan.gallus@iul.tu-dortmund.de

Sigrid Hess M. Sc.
0231 755 8451
sigrid.hess@iul.tu-dortmund.de

Eike Hoffmann M. Sc.
0231 755 6926
eike.hoffmann@iul.tu-dortmund.de

Mike Kamaliev M. Sc.
0231 755 8440
mike.kamaliev@iul.tu-dortmund.de

Anna Komodromos M. Sc.
0231 755 8420
anna.komodromos@iul.tu-dortmund.de

Juri Martschin M. Sc.
0231 755 8437
juri.martschin@iul.tu-dortmund.de

Rickmer Meya M. Sc.
0231 755 2669
rickmer.meya@iul.tu-dortmund.de

Siddharth Upadhya M. Sc.
0231 755 7430
siddharth.upadhya@iul.tu-dortmund.de

Abteilung Sonderverfahren | Non-Conventional Processes

Marlon Hahn M. Sc.
Abteilungsleiter Sonderverfahren
0231 755 8415
marlon.hahn@iul.tu-dortmund.de

Hamed Dardaei M. Sc.
0231 755 7851
hamed.dardaei@iul.tu-dortmund.de

Siddhant Goyal M. Sc.
0231 755 7431
siddhant.goyal@iul.tu-dortmund.de

Dr.-Ing. Dipl.-Wirt.-Ing. Jörn Lueg-Althoff
Projektmanager ReCIMP
0231 755 6922
joern.lueg-althoff@iul.tu-dortmund.de

Fabian Maaß M. Sc.
0231 755 2607
fabian.maass@iul.tu-dortmund.de

Stephan Rosenthal M. Sc.
0231 755 6441
stephan.rosenthal@iul.tu-dortmund.de

Lennart Tebaay M. Sc.
0231 755 8434
lennart.tebaay@iul.tu-dortmund.de

Florian Weber M. Sc.
0231 755 2608
florian.weber@iul.tu-dortmund.de

Sebastian Wernicke M. Sc.
0231 755 7429
sebastian.wernicke@iul.tu-dortmund.de

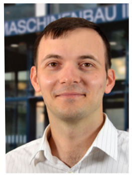
Projektierung | Project planning

Dr.-Ing. Dipl.-Wirt.-Ing. Soeren Gies
Abteilungsleiter Projektierung
0231 755 5238
soeren.gies@iul.tu-dortmund.de

Dr.-Ing. Dipl.-Wirt.-Ing. Ramona Hölker-Jäger
Leiterin der Arbeitsgruppe ReGAT (in Elternzeit)
0231 755 6915
ramona.hoelker@iul.tu-dortmund.de

Dipl.-Wirt.-Ing. (FH) Kerstin Lenschen
0231 755 2034
kerstin.lenschen@iul.tu-dortmund.de

Dr.-Ing. Frauke Maevus
Geschäftsführerin SFB/TRR 188
0231 755 8193
frauke.maevus@iul.tu-dortmund.de



Oleksandr Mogylenko M. Sc.
0231 755 7174
oleksandr.mogylenko@iul.tu-dortmund.de

Dipl.-Inform. Alessandro Selvaggio
0231 755 7228
alessandro.selvaggio@iul.tu-dortmund.de

Technische Mitarbeiter | Technical Staff

Dipl.-Des. (FH) Patrick Cramer
0231 755 2456
patrick.cramer@iul.tu-dortmund.de

Ilias Demertzidis
0231 755 6606
ilias.demertzidis@iul.tu-dortmund.de

Werner Feurer
0231 755 2609
werner.feurer@iul.tu-dortmund.de

Dipl.-Ing. (FH) Andreas Herdt
0231 755 7288
andreas.herdt@iul.tu-dortmund.de

Dirk Hoffmann
0231 755 6605
dirk.hoffmann@iul.tu-dortmund.de

Sven Lukies
0231 755 6062
sven.lukies@iul.tu-dortmund.de

Dipl.-Ing. (FH) Michael Prüfert
0231 755 6924
michael.pruefert@iul.tu-dortmund.de

Steffen Strotzer
0231 755 7289
steffen.strotzer@iul.tu-dortmund.de

Frank Volk
0231 755 5247
frank.volk@iul.tu-dortmund.de

2019 ausgeschieden | Staff who left in 2019

Dr.-Ing. Christoph Dahnke

Dipl.-Ing. Thomas Mennecart

Oliver Napierala M. Sc.

Dipl.-Ing. Tobias Ortelt

Dr.-Ing. Peter Sieczkarek

Dipl.-Ing. Daniel Staupendahl