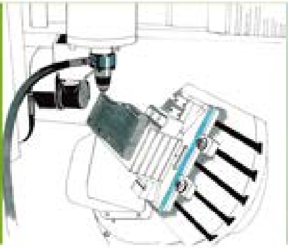
Institute of
Forming Technology and
Lightweight Construction

Activity Report

15

technische universität
dortmund

Institut für Umformtechnik und Leichtbau

Activity Report

15

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Imprint

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Preface

Dear Readers,

Political events in 2015 were dramatic and upsetting. The terror attacks in France and other countries shocked us all and the Institute of Forming Technology and Lightweight Construction (IUL) stood shoulder to shoulder especially with our French friends and colleagues. The ongoing refugee drama calls for support from all people and institutions in the safe European countries. IUL´s old administrative building, which was supposed to be torn down already in 2015, is now ready to be used, for the time being, as emergency accommodation for refugees. On short notice, we have opened our lectures for interested refugees. It is obvious, however, that we will have to do even more for these people, who were ripped out of their homelands, and we will actively do so in the New Year.

On the other hand, 2015 was a very successful research year for the Institute. A major equipment initiative proposal submitted to the German Research Foundation (DFG) and The Ministry of Innovation, Science, Research and Technology of the State of North Rhine-Westphalia for the acquisition of a combination machine for laser deposition of powder in a 5-axis machining center was approved and now marks the beginning of a new line of research at the IUL. With this machine, we can implement and investigate our patent-pending method for combining additive, subtractive, and formative manufacturing processes. From this combination method, we expect a drastic reduction of the energy brought into the products and an increased manufacturing speed compared to products manufactured by a purely additive process.

On 1 August 2015, the „Research Group on Additive Manufacturing“ (ReGAT) was launched to collate IUL´s different research activities around the combination of additive and formative manufacturing methods. Dr. Ramona Hölker-Jäger established this new work group and is its leader. We were very delighted and motivated to do extensive research in this challenging new territory when the Senate Committee for the Collaborative Research Centers of the German Research Foundation (DFG) recommended submitting a proposal on establishing a Collaborative Research Center on damage-controlled forming processes together with RWTH Aachen University and the Max-Planck-Institut für Eisenforschung GmbH (MPIE). Furthermore, the approval by the BMBF (Federal Ministry of Education and Research) of the transregional joint research project ELLI2 confirms our concept on engineering education, which is put into practice by the interdisciplinary cooperation between didactics of higher education and engineering sciences. We are very much looking forward to continuing and extending the excellent and well-established co-operation in the jointly applied for collaborative research project with Professor Sabina Jeschke of RWTH Aachen University and Professor Marcus Petermann of Ruhr-Universität Bochum as well as their teams.

The activities of the “Research Center for Industrial Metal Processing (ReCIMP)“, which was established in 2012 in the framework of a research project with the global corporation Faurecia, were further extended and strengthened in 2015. This reveals the great demand for and of such a research group, that does not only perform applied research activities in co-operation with the industry but also generates numerous innovative, practical, and fundamentals-oriented research projects.

In 2015, the number of staff members has risen slightly: Six new members joined the Institute and five left to take up new challenges in the industry after their academic careers. Again this year, the graduates of our study programs showed a high interest in working at the IUL, which is reflected in the employment of three new candidates from our own pool of students. With five completed doctoral theses and 49 diploma, master´s, bachelor, project, and student theses, we had an overall very successful academic year.

The fifth student generation of the international master study program “Manufacturing Technology“ (MMT) started their studies in October 2015. This year again, the high number of international applications encouraged us to continue our international commitment with this study program. The participation of MMT students in research activities of the chairs and institutes of the Department of Mechanical Engineering has risen from year to year and has become an integral part of our research potential.

In 2015, the IUL again organized several events. Apart from the 18th workshop on “Simulation in Forming Technology” and the internationally attended “3rd Industrial Colloquium of the CRC/TR 73 (SFB/TR 73)”, the colloquium which was held on the occasion of Matthias Kleiner´s 60th birthday certainly was a highlight in the academic calendar of the IUL. Numerous guests from academia and industry followed the invitation to attend the event, which was orga-nized as a surprise for the jubilarian. The excellent international contributions in the book “60 Excellent Inventions in Metal Forming“, which was published on the occasion of this birthday, recognize the great progress in the forming technology area in the last decades. The Industrial Advisory Board, as well, celebrated a small anniversary with its 10th meeting. The IUL highly appreciates the numerous suggestions and constructive criticism offered by the members of the Board.

The numerous renowned guests, who visited the IUL for a long-term research stay, constitute an essential part of the international networking of the Institute. Professor Misiolek (USA), Professor Martins (Portugal), Professor Lei (China), Dr. Kim (Korea), Dr. Lou (China), Mr. Sumikawa (Japan), and several students from USA and Japan performed valuable research work at the IUL. These research stays were made possible thanks to the Alexander von Humboldt Foundation, the German Research Foundation (DFG), the Korea Institute of Materials Science (KIMS), the China Scholarship Council (CSC), and the German Academic Exchange Service (DAAD). The successful international co-operation within the worldwide research community is of great importance to the IUL – not only for the successful research work but also for the trust and friendships that result. We would like to thank our guests and international partners most cordially for this fruitful co-operation.

We are especially proud of the numerous prizes we were awarded this year. The "Best Paper Prize" of the ICEB 2015, the "Stahl-Innovationspreis 2015" (steel innovation award), and the "Zwick Science Award 2014" were a great honor and motivated us tremendously.

The success of the Institute of Forming Technology and Lightweight Construction could not have been achieved without the dedicated commitment of all staff members, the support provided by research funding institutions, the co-operation with industrial companies, the interconnection in the international research community, and the maintenance of close ties with the university colleagues in Dortmund and other locations. Our heartfelt thanks go to all of them.

A. Erman Tekkaya

Matthias Kleiner

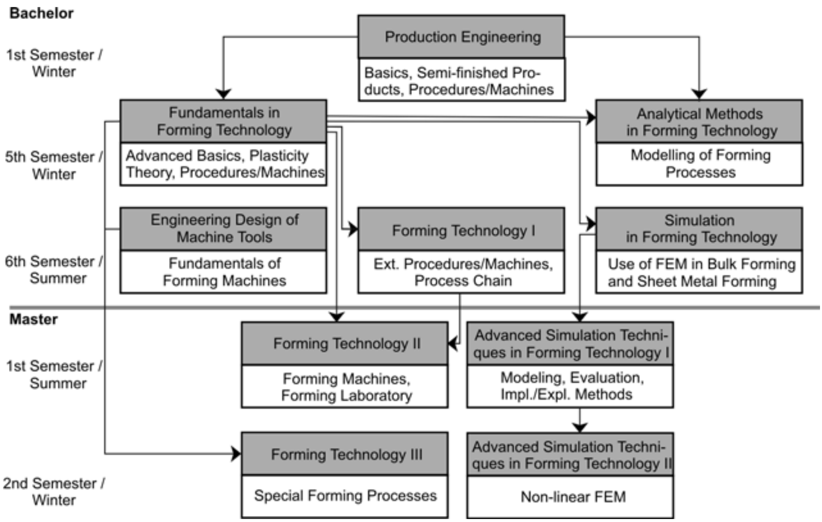
Education

01

1 Education

1.1 Offered Courses

The Institute of Forming Technology and Lightweight Construction teaches mainly bachelor and master students majoring in logistics, industrial engineering, and mechanical engineering. In addition, the lectures are attended by students of education, computer science, and physics in their minor subject. In this way, the students gain the knowledge and skills which are necessary for a successful career entry in industry or research. In the following, the individual lectures are presented.



Structure of lectures e.g. of the study program mechanical engineering with specialization in production engineering (all above courses are tought in German)

Further courses of the institute are:

- MMT I – Forming Technology – Bulk Forming (in English)
- MMT II – Forming Technology – Sheet Metal Forming (in English)
- MMT III – Advanced Simulation Techniques in Metal Forming (in English)
- MMT IV – High dynamic Testing of Materials (in English)
- MMT V – Additive Manufacturing (in English)

- Industrial Lecture Course: Industrial Field Reports (basically in German)
- Laboratory work A for Students of Mechanical Engineering (basically in German)
- Laboratory work B for Students of Industrial Engineering (basically in German)
- MMT Laboratory work (in English)

The lecture “additive manufacturing”, which was offered for the first time in the winter semester 2015/16, describes the principles and characteristics of the layer-wise production of components. Firstly, the lecture deals with topics regarding the generation of manufacturing data as a part of the process chain, which is divided into the steps of data preparation, data conditioning, and data processing. One of the main emphases of the lecture is the description and explanation of the most important AM processes, which commercially available technologies are based upon. These include Stereolithography, Laser Sintering, Laser Beam Melting, Fused Layer Modeling, MultiJjet Modeling, Poly Jet Modeling, 3D-Printing, Layer Laminated Manufacturing, and Digital Light Processing. As additional contents, various methods for post processing of components are discussed in the lecture as well as the cost effectiveness depending on different factors.

In 2015, the following guest professors and lecturers participated in the educational offers of the IUL:

- Prof. P. Haupt, Emeritus University of Kassel
- Prof. K. Roll, formerly Daimler AG Sindelfingen
- Dr. E. Lach, ISL – French-German Research Institute of Saint-Louis, France
- Dr. H. Schafstall, Simufact Engineering GmbH, Hamburg
- Dr. J. Vochsen, SMS Meer GmbH Moenchengladbach
- Dr. J. Sehrt, University of Duisburg-Essen

Further information at www.iul.eu/lehre (or using the following QR code)

1.2 Master of Science in Manufacturing Technology (MMT)

Program start October 2011
Coordination Prof. Dr.-Ing. Dr.-Ing. E.h. A. E. Tekkaya
M.Sc. O. Napierala • Dipl.-Fachübers. A. Hallen

About 60 excellent students from more than 20 different countries are currently enrolled in the English-language, four-semester master study program in the field of manufacturing technology.

With the newly introduced lectures "Plastics Technology" and "Additive Manufacturing" the technical elective course offer could be extended again as planned, thereby taking into account new developments in research and technology.

Furthermore, the German language course offer was adapted to the students´ present needs. German language skills are not a requirement to complete the MMT study program. However, for an employment in Germany, they are almost indispensable. For this reason, two new German language classes, level A1 and A2, especially for MMT students have been installed in addition to the regular courses offered by TU Dortmund University to all students.

Program overview

	1st semester	2nd semester	3rd semester	4th semester
Comp. module 1	Machining technology			
Comp. module 2	Materials technology			
Comp. module 3	Forming technology			
Elective module 1	Elective 1 - Part 1	Elective 1 - Part 2		
Elective module 2	Elective 2 - Part 1	Elective 2 - Part 2		
Elective module 3	Elective 3 - Part 1	Elective 3 - Part 2		
Laboratory work			Laboratory work	
Project work			Project work	
Interdiscipl. qual.			Interdiscipl. qual.	
Master's thesis				Master's thesis

The MMT online application portal could once more be considerably 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 applicants´ data and the subsequent selection of the students to be admitted have become even more convenient and efficient.

A total of 19 selected excellent students from seven different countries started their studies in the MMT program in the winter semester 2015/16. Before the start of the lecture period, they were welcomed in person by Professor Tekkaya in his function as head of the MMT study program in the frame of a welcoming event in the experimental hall of the IUL:

Welcome to the new MMT batch in the IUL experimental hall...

...with interesting presentations and...

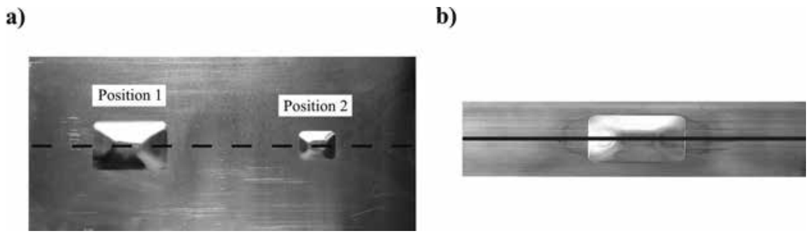
...time to meet and talk.

For further information please click www.mmt.mb.tu-dortmund.de or use the following QR code:

1.3 Doctoral Theses

Cai, Sheng	Tailored and Double-Direction Pressure Distributions for Vaporizing Foil Forming
Series	Dortmunder Umformtechnik
Publisher	Shaker Verlag, Aachen, 2016
Oral exam	December 18, 2015
Advisor	Prof. Dr.-Ing. Dr.-Ing. E.h. A. E. Tekkaya
Co-examiner	Prof. Dr. -Ing. F. Vollertsen (Bremer Institut für angewandte Strahltechnik)

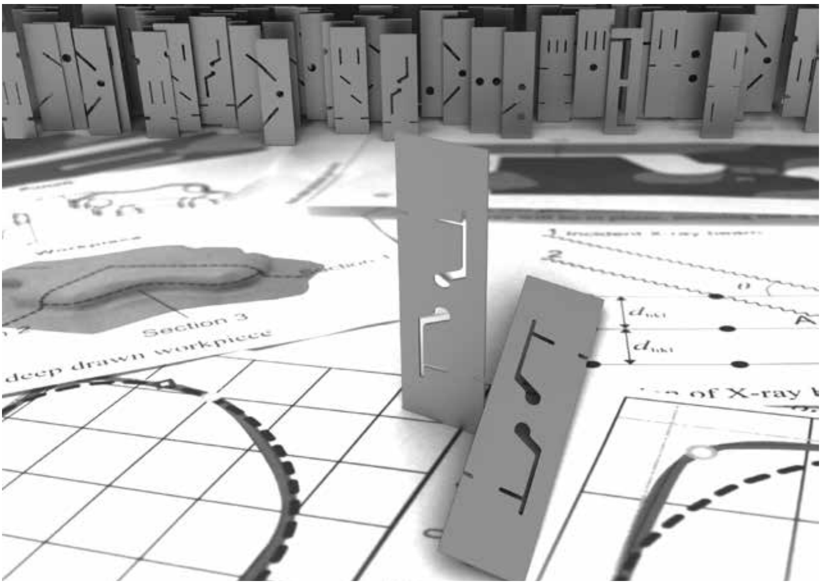
By applying high speed forming methods like electromagnetic forming, forming limits of classical quasi-static processes can be exceeded to higher value and spring-back can be reduced. Electromagnetic forming is currently the most widely applied high speed forming method. However, electromagnetic forming requires high electrical conductivity of the workpiece and expensive tool coils. Metal wires or foils can be vaporized when high currents are applied. The generated metal gas or plasma provides the pressure pulse to the sheet metal, which results in a deformation of the sheet. This process requires no electrical conductivity of the workpiece and no expensive coils.
In the present work an analytical model to predict the shock pressure amplitude is developed. Based on the investigations of the process parameters, two new pressure distributions are realized. The tailored pressure distribution is supposed to reduce the rebound effect in high speed forming processes while the multiple pressure distribution provides a new option for profile forming and could be used to improve the productivity as well.



a) Sheet metal forming by tailored pressure distribution, b) Profile forming by multiple pressure distribution

Güner, Alper	In-Situ Stress Analysis with X-ray Diffraction for Yield Locus Determination
Series	Dortmunder Umformtechnik
Publisher	Shaker Verlag, Aachen, 2015
Oral exam	January 9, 2015
Advisor	Prof. Dr.-Ing. Dr.-Ing E.h. A. E. Tekkaya
Co-examiner	Prof. Dr. rer. nat. W. Reimers (TU Berlin)

One of the main problems in the field of sheet metal characterization are the inhomogeneous deformation fields caused by edge effects. For the calculation of the yield stresses globally acting tool forces and a single averaged value for the instantaneous gauge area are used. Hence, the inhomogeneity is an error source for the analytical determination of yield stresses. The X-ray diffraction method is introduced to solve the problem caused by inhomogeneous deformation fields in the sheet specimens. In the proposed strategy the strains on the specimen surface are captured by an optical measurement system during testing. At the same time, the loading stresses in the gauge zone are measured by means of an X-ray diffractometer installed on a standard universal testing machine. The proposed method was applied to obtain the yield locus. There, a novel specimen geometry was utilized to realize multiple deformation states.



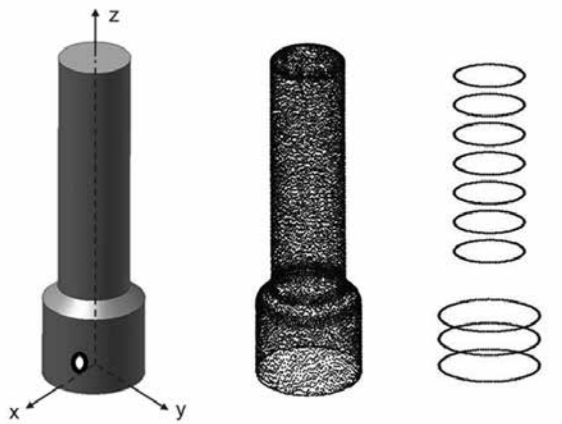
The novel multi-state specimen

Hänisch, Stephan	Distortion Analysis of Cold Forged and Heat Treated Components
Original Title	Verzugsanalyse kaltmassivumgeformter und wärmebehandelter Bauteile
Series	Dortmunder Umformtechnik
Publisher	Shaker Verlag, Aachen, 2015
Oral exam	May 7, 2015
Advisor	Prof. Dr.-Ing. Dr.-Ing. E.h. A. E. Tekkaya
Co-examiner	Prof. Dr.-Ing. habil. F. Hoffmann (IWT Bremen)

During the widespread production process of cold forging and subsequent heat treatment undesirable dimensional and shape changes of the components can occur. The sources of distortion and the effects of various parameters are still not entirely clear. Within the scope of this work, the relations between cold forging, heat treatment, and distortion have been investigated on the basis of forward rod extrusion.

In extensive series of experiments different parameters along the process chain such as material, plastic strain, or heat treatment were varied and the component properties were investigated. Based on the measured geometrical changes between the individual process steps, the effects of various factors were analyzed and their significances were determined. In addition to the experimental work, the residual stresses as distortion potential carrier were analyzed by means of numerical methods with two-dimensional and three-dimensional FEA models as well as the impact of asymmetric interference on the residual stress distribution and the shape deviation was examined.

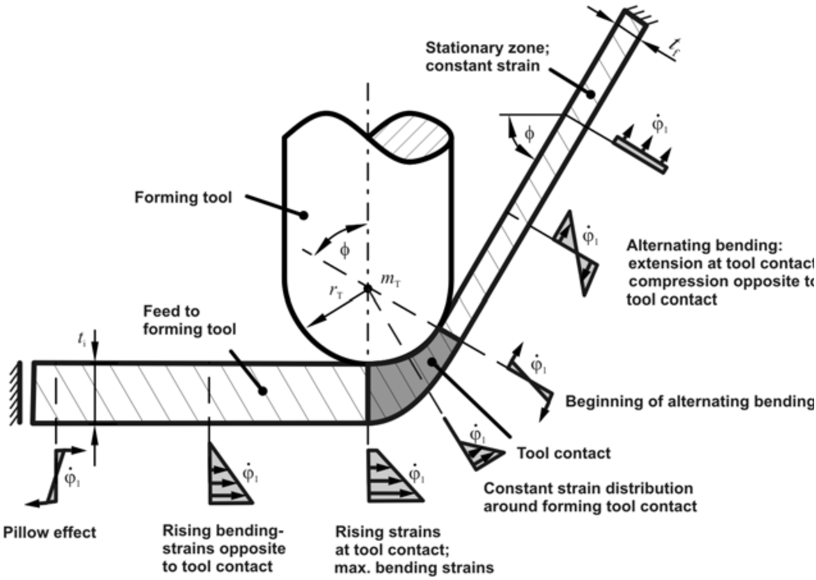
It is shown that, in addition to material, lubricant, and plastic strain, in particular the cooling rates during case hardening have an influence on distortion and the factors are partly interacting. Based on the results, some approaches to reduce the distortion are suggested.



Point cloud by optical and tactile component measurement

Sebastiani, Gerd	Extending the Incremental Sheet Forming Process by Means of Flexible Tools
Original title	Erweiterung der Prozessgrenzen inkrementeller Blechumformverfahren mittels flexibler Werkzeuge
Series	Dortmunder Umformtechnik
Publisher	Shaker Verlag, Aachen, 2016
Oral exam	December 14, 2015
Advisor	Prof. Dr.-Ing. Dr.-Ing E.h. A. E. Tekkaya
Co-examiner	Prof. Dr.-Ing. W. Homberg (Paderborn University)

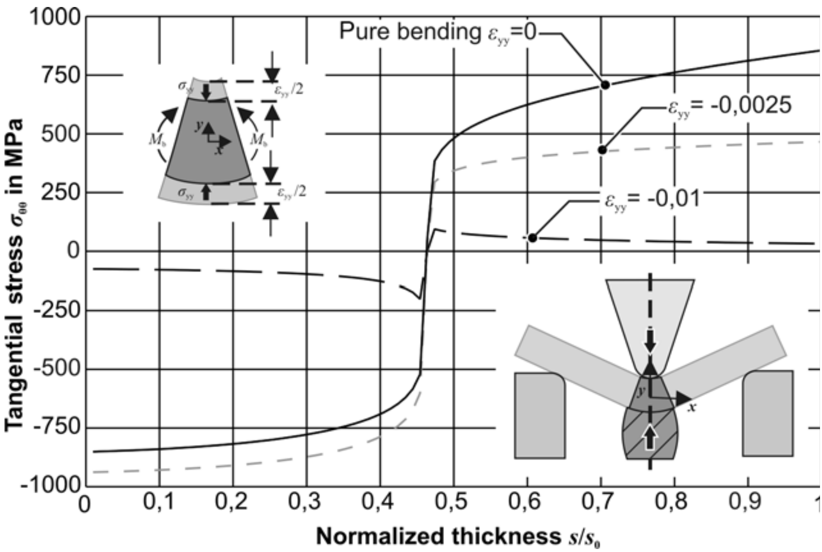
What causes the achievable strains in incremental sheet forming? The present work investigates this question and describes the analysis of the underlying mechanical principles in order to develop tools for reinforcing denoted principles. With this aim, measuring methods are developed in order to analyze the progression of the deformation in the forming zone. Based on the knowledge obtained, a fundamental mechanical model of the process is developed. Increasing the forming limits is accomplished by the development of supporting tools whose effectiveness is verified in case studies. As a rapid prototyping process, the incremental sheet forming requires a tool which is adaptable to different forming tasks. Therefore, the flexible tool concept FlexDie is used, which is optimized in a case study with respect to the achievable part quality as well as economical aspects.



Experimentally identified, mechanical effects ahead, within and after the tool contact

Weinrich Mora, Andres	Air Bending with Incremental Stress Superposition
Original title	Das Freibiegen mit inkrementeller Spannungsüberlagerung
Series	Dortmunder Umformtechnik
Publisher	Shaker Verlag, Aachen, 2016
Oral exam	November 23, 2015
Advisor	Prof. Dr.-Ing. Dr.-Ing. E.h. A. E. Tekkaya
Co-examiner	Prof. Dr.-Ing. W. Homberg (Paderborn University)

Sheet bending processes are characterized by high springback. A reduction of the springback can be realized by applying the incremental stress superposition to air bending. The aim of this work is to provide the basics of this new process. Analytical models of pure bending, air bending, and stress superposition have been developed. All analytical models have been validated by FEM and, if obtainable, by experimental results. A comparison with other bending processes has been done. The focus was on springback and the forming operations. Other positive aspects like the application of stress superposition to tailored blanks or an enhancement of the forming limits are presented in this work. The presented results describe the new process comprehensively.



Stress reduction by stress superposition

Research for Engineering Education

02

2 Research for Engineering Education

Excellent education is based on excellent research and excellent research needs excellent educated engineers. Therefore, teaching must be adjusted to current topics like digitization or Industry 4.0 (German term for cyber physical systems). Several projects were designed at the IUL for a sustainable development of engineering education in interaction with research for teaching and learning. The main focus of attention in the field of engineering education research is the science based investigation on learning in engineering laboratories. With laboratories or by performing experiments, students are able to combine theory with practical relevance. This connection can be reached by different approaches. On the one hand, the ELLI tele-operative testing cell for material characterization provides a location and time independent access to experiments via the internet. On the other hand, live experiments are integrated into lectures and students can use their own mobile devices to answer polls during the lectures live and anonymously. So didactical concepts are combined with new technologies.

List of projects:

- ELLI – Excellent Teaching and Learning in Engineering Science
- IngLab – The Laboratory within Engineering Education
- KoM@ING – Modeling and development of competences related to mathematics and its application in engineering studies
- MINTReLab – International Manufacturing Remote Lab (Project of the Faculty of Mechanical Engineering)

2.1 ELLI – Excellent Teaching and Learning in Engineering Education

Funding	BMBF/DLR
Project-ID	01 PL 11082 C
Project leader	Prof. Dr.-Ing. Dr.-Ing. E.h. A. E. Tekkaya
Contact	Dipl.-Ing. T. R. Ortelt Dipl.-Inf. A. Selvaggio M.Sc. R. Meya Dr.-Ing. habil. S. Chatti

The trans-regional joint research project of RWTH Aachen University, Ruhr-Universität Bochum and TU Dortmund University is funded by the Federal Ministry of Education and Research. ELLI is devided in four different fields:

- Virtual learning environments
- Support of mobility and internationality
- Student lifecycle
- Creativity and interdisciplinarity

At TU Dortmund University the IUL collaborates with colleagues of the Center for Higher Education (zhb). The IUL principally works on two sub-projects of the first field “virtual learning environments”:

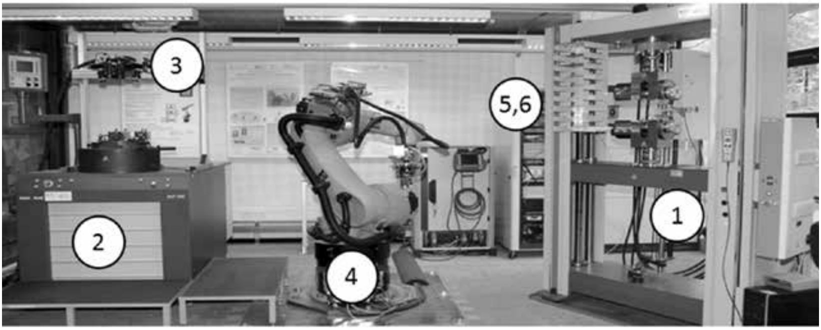
- Investigation on lab courses in engineering education
- Development and integration of remote and virtual labs

The first sub-project “Investigation on lab courses in engineering education” is almost finished. Current topic is the evaluation of the tele-operative testing cell. The evaluation is done with the help of the zhb and focuses on two different levels, i.e., technology and teaching or learning. The results of this evaluation lead to a continuous improvement of the experiments.

The second sub-project “Development and integration of remote and virtual labs” deals with the development of a tele-operative testing cell for material characterization. The following picture shows the tele-operative testing cell at the IUL and its components:

1) Universal testing machine Zwick Z 250
2) Sheet metal testing machine Zwick BUP 1000
3) Optical measuring system GOM ARAMIS 4M

4) Industrial robot KUKA KR30-3
5) Realtime control system from National Instruments
6) Safety system SICK
and Camera system



Tele-operative testing cell at IUL

Current developments aim at the integration of new experiments into the tele-operative testing cell. During the winter semester 2015/2016 two new experiments were first performed during lecture “Umformende Fertigungs-technologien” (Fundamentals in Forming Technology). A tele-operative tensile test with hot specimen temperature (up to 1000 °C) was controlled from the lecture hall in interaction with the students. Before the start of the experiment, the temperature was chosen by a student and the experiment was observed by live camera feeds and real-time measured data. Furthermore, the automation of the sheet metal testing machine Zwick BUP 1000 was finished. A deep drawing test according to Swift, to determine material properties relevant for forming technology, is now tele-operatively available. During the first performance of this new experiment the configuration was done by the lecturer in interaction with the students.

Furthermore, current activities aim at the automation of the Nakajima experiment to determine forming limit curves (FLC) and at the automation of the compression test.

The integration of an industrial manufacturing process, incremental tube forming, by developing a tele-operative control interface was started. Ideas of Industrie 4.0 (a German keyword for digitization in the field of production), like the controlling of machines via internet, influences this development. The main aim focuses on the learning outcome of students because they are able to conduct an experiment of springback reduction and observe the forming effect of stress superposition.

The tele-operative testing cell was repeatedly used during an online course for new international students of the master study program Manufacturing Technology (MMT). These students conducted an experiment via internet from their home country (such as India, Iran, Nepal, or Mexico) before they have ever been to Dortmund.

In a next step, the tele-operative testing cell will be used in a new scenario for pupils of middle school. Therefore, the experiments have to be adjusted to a different level. In a course of physics, the pupils should do experiments on their own and calculate material properties, like Young's modulus, applying their mathematical knowledge.

Results of the ELLI project were presented at national and international conferences like "ELEARN 2015 – World Conference on E Learning".

In November 2015 it has announced that the Federal Ministry will continue to fund ELLI in its second funding period from October 2016 until December 2020. On the one hand, the IUL will work on the expansion of the tele-operative testing cell and the integration of new experiments. On the other hand, the focus will be on new technologies for engineering education, like virtual and augmented reality.

2.2 IngLab – The Laboratory in Engineering Science Education

Funding	acatech - NATIONAL ACADEMY OF SCIENCE AND ENGINEERING e. V.
Project leader	Prof. Dr.-Ing. Dr.-Ing. E.h. A. E. Tekkaya
Contact	Dipl.-Ing. T. R. Ortelt M.Sc. M.Eng. C. Pleul Dr.-Ing. F. Maevus
Status	Completed

The interdisciplinary project "IngLab – The Laboratory within Engineering Education" was finished in May 2015. Researcher of the IUL collaborated with experts of the Center for Higher Education (zhb) of TU Dortmund University. The main aim of this project was the development of guidelines for laboratories in engineering education. The connection of theory and practice is often done by conducting experiments in engineering education. Therefore, the examination of theory and the own procedure during the experiment is very important for laboratories.

German and international experts were interviewed about their assessment of laboratories in engineering education. With these assessment and the analysis of 18 manufacturing laboratories, a total of 25 guidelines were developed. These guidelines will be published in an "acatech Studie (study)" soon and are divided into three topics.

- Subject-specific oriented (11 guidelines)
- Didactical oriented (9 guidelines)
- Organizational oriented (5 guidelines)

2.3 KoM@ING – Modeling and Development of Competences according to Mathematics and its Substitution in Engineering Studies

Funding	BMBF/DLR
Project	01PK11021A
Project leader	Prof. Dr.-Ing. Dr.-Ing. E.h. A. E. Tekkaya
Contact	Dipl.-Ing. T. R. Ortelt
Status	Completed

The project KoM@ING was divided into three subprojects and was finished in May 2015. Researchers of Leuphana University of Lüneburg, University of Paderborn, Humboldt-Universität zu Berlin, TU Dortmund University, University of Stuttgart, and IPN – University of Kiel worked on the development of a competences model for the required mathematic skills in engineering studies.

In the subproject B, the IUL was collaborated on an interdisciplinary basis with the colleagues of the Center for Higher Education (zhb) of TU Dortmund University and colleagues of Berlin on the development of a competences model for mathematical competences in the context of laboratory learning for engineering studies.

The following working packages were treated under the leadership of the zhb in 2015:

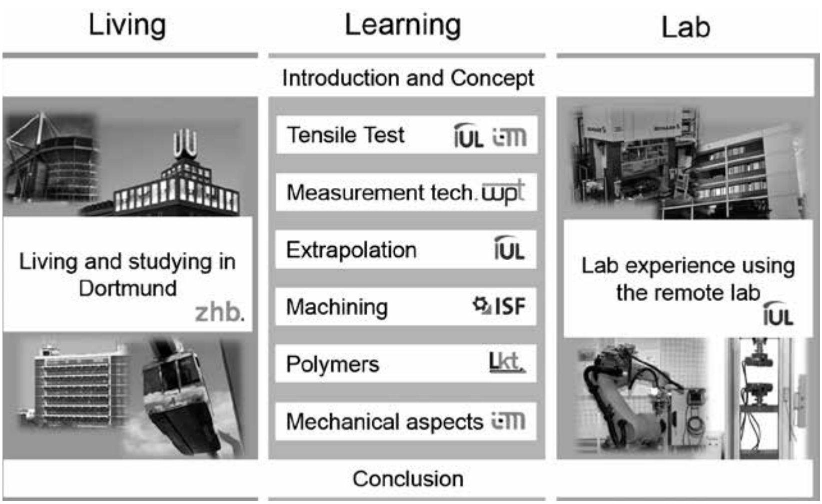
- WP 6: First performance of the developed instruments
- WP 7: Synthesis and systematization

In June 2015 the last workshop meeting with all colleagues of all institutions took place in Kassel. The results of the different subprojects were presented and new approaches for further studies were discussed.

2.4 MINTReLab – International Manufacturing Remote Lab (Project of the Faculty of Mechanical Engineering)

Funding	Stifterverband
Project leader	Prof. Dr.-Ing. Dr.-Ing. E.h. A. E. Tekkaya (as the Dean of the Faculty of Mechanical Engineering)
Contact	Dipl.-Ing. T. R. Ortelt

In the project "MINTReLab – International Manufacturing Remote Lab" five different partners of the Faculty of Mechanical Engineering (Department of Materials Test Engineering (wpt), Institute of Mechanics (im), Institute of Machining Technology (ISF), Institute of Forming Technology and Lightweight Construction (IUL), Chair of Polymer Technology (LKT)), and experts of the Center for Higher Education (zhb) are developing a MOOC (Massive Open Online Course). The course will deal with the unidimensional tensile test from different subject-specific views. The different chapters are batched and the tele-operative testing cell of the IUL is integrated for experiments. The remote lab should combine theory with practical relevance with different point of views. In addition to that, the MOOC should also advertise studies in Germany, and especially at TU Dortmund University, by showing social aspects of the life in the Ruhr District. Therefore, the MOOC is divided into three parts (Living, Learning, Lab).



Concept of the MINTReLab MOOC

Research

03

3 Research

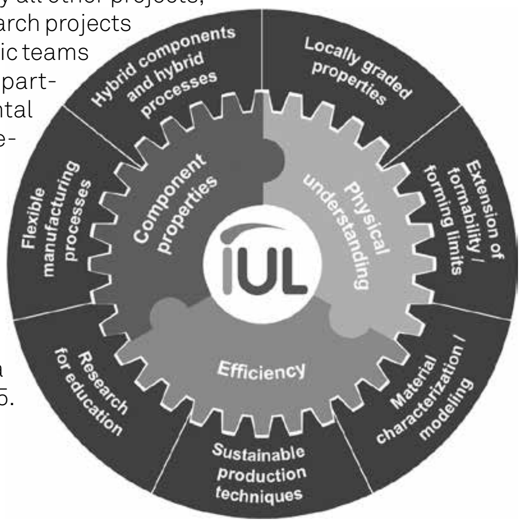
The research activities of the Institute of Forming Technology and Lightweight Construction pursue three main objectives. The acquirement of physical understanding of forming processes, the setting and improvement of component properties, , and a holistic view on effi ciency are the aims of the departments Sheet Metal Forming, Bending, Bulk Metal Forming, Non-Conventional Processes, and Applied Mechanics in Forming Technologies.

Research focuses on the following main topics:

- Flexible manufacturing processes
- Hybrid components and hybrid processes
- Locally graded properties
- Extension of formability/forming limits
- Material characterization/modeling
- Research for education
- Sustainable production techniques (Recycling)

The IUL departments are complemented by the ReCIMP - Research Center for Industrial Metal Processing and the ReGAT – Research Group on Additive Technology. As with basically all other projects, the ReCIMP and ReGAT research projects are assigned to issue-specific teams working both at an intradepartmental and interdepartmental level, depending on the required expertise.

2 chief engineers, 39 scientists, 5 visiting researchers, 14 technicians and administrative staff members, and approximately 50 student assistants ensured a sustainable success in 2015.



Research objectives of the Institute of Forming Technology and Lightweight Construction

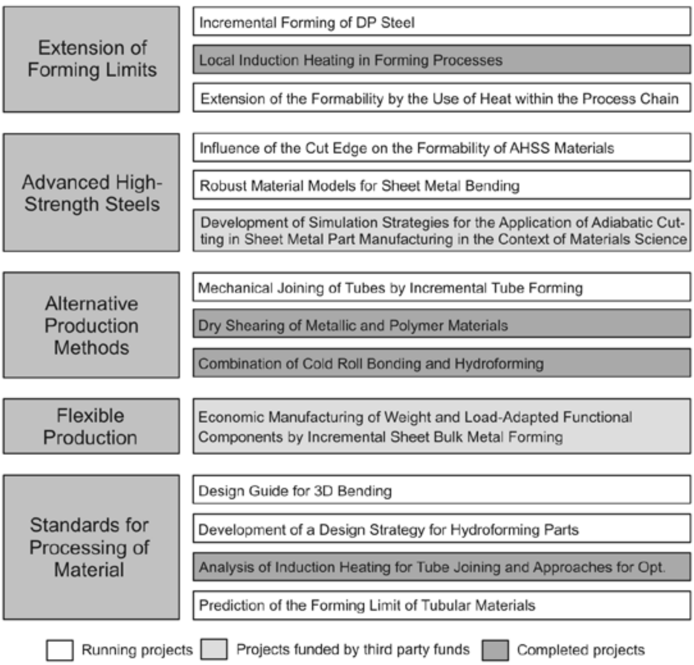
3.1 Research Groups and Centers

3.1.1 ReCIMP – Research Center for Industrial Metal Processing

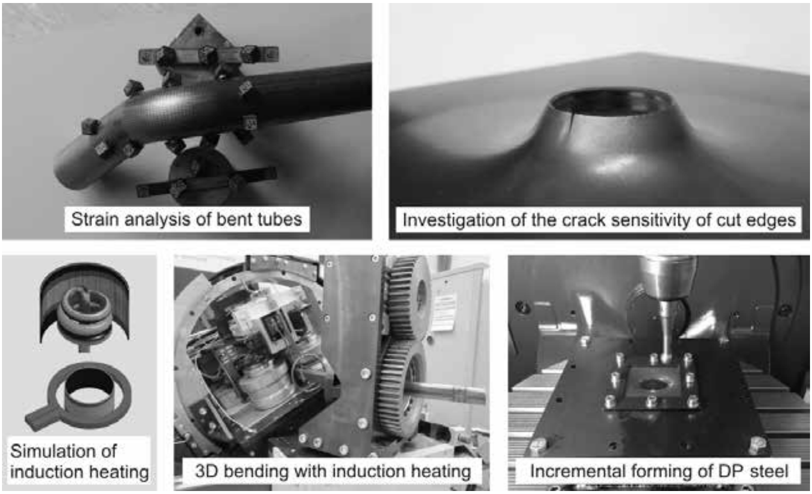
Head Dipl.-Ing. D. Staupendahl

The "Research Center for Industrial Metal Processing" (ReCIMP) was founded in 2013 in cooperation with the international automotive supplier Faurecia and aims at advancing and deepening scientific knowledge on innovative metal production processes, process chains and hybrid processes, the analysis of new scientific trends in metal processing, and networking with leading research institutes and companies. Together with the Faurecia groups "Automotive Seating" and "Emissions Control Technologies", five core research fields were set up as seen in the following figure. The figure also gives an overview of the projects that ReCIMP worked on in 2015.

In the automotive industry advanced high-strength steels (AHSS) are one of



Current ReCIMP research projects



A selection of research activities performed by ReCIMP

the key elements in the realization of lightweight design and, in effect, a reduction of the CO2 footprint. The necessity to reduce costs and save valuable resources also leads to the replacement of currently used steels by steels with a higher value to cost ratio as in the case of choosing ferritic over austenitic stainless steel for exhaust applications. Since both, AHSS and ferritic stainless steel, feature a low formability, methods for the extension of forming limits are investigated. One possibility is the use of heat during the forming process or between process steps. This approach is being investigated in the project Extension of the Formability by the Use of Heat within the Process Chain, which is described later in this report. Here, local induction heating can reduce process costs and cycle times.

Another method to increase the formability of AHSS is the use of incremental forming methods, with the forming process being cut down into a multitude of single small forming steps which are characterized by complex states of stresses that, in turn, extend the forming limits of the sheet metal. Additional to investigating the forming bevavior of DP steels, the current research focuses on the decrease of the process time.

Apart from allowing the design of efficient lightweight applications, AHSS tend to be sensitive to crack formation on cut edges. This can actually lead to part failure during forming processes that follow upstream cutting operations. To classify materials for the use in various forming processes, the project Influence of the cut edge on formability was established. It shares the aim of predicting material failure using finite element simulations with the project "Robust material models for sheet metal bending", which is described later in this report.

An important research activity within ReCIMP is the investigation of alternative production methods to currently used processes. The project "Mechanical joining of tubes by incremental tube forming", also described in this report, was set up to investigate the usability of mechanical joints in high temperature applications as an alternative to brazing or welding. Also cold roll bonding was investigated as an alternative method to welding in the production of heat exchangers.

Apart from flexible production methods, the setting up of standards for the processing of metal is a requirement to provide an efficient work flow. Especially for complex processes with a large number of variable parameters, as for instance 3D profile bending, design guides can be used for knowledge transfer. In the project "Development of a design strategy for hydroforming parts with secondary forming elements" a guideline for designers is developed to reduce design-simulation-loops. This is done by setting up a process simulation and varying relevant geometry, process, and material parameters and by analyzing their impact on the formability.

Altogether, fourteen separate projects were carried out in 2015, four of which were successfully completed in the same year. One of these was the project "Dry shearing of metal material and polymers", third-party funded by the AiF/FOSTA and described later in this report. In contrast, two new third-party funded projects started in 2015. The AiF/FOSTA funded projects "Economic manufacturing of weight and load-adapted functional components by incremental sheet bulk metal forming" and "Development of simulation strategies for the application of adiabatic cutting in sheet metal part manufacturing in the context of material science", both described later in this report.

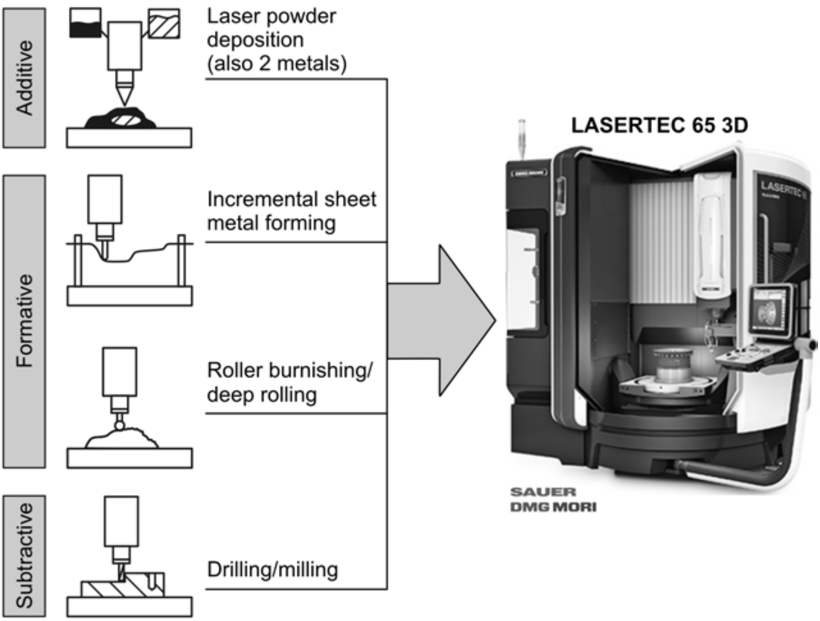
Eight researchers and six student researchers were involved in ReCIMP projects in 2015. Furthermore, three master theses, one diploma thesis, and four student research projects were completed and two master theses and six student research projects are still running. This team setup provides an optimal basis for high level research activities and continuous input of new ideas of industrial relevance.

3.1.2 ReGAT – Research Group on Additive Technology

Head Dr.-Ing. Dipl.-Wirt.-Ing. R. Hölker-Jäger

Additive manufacturing processes develop progressively from prototype manufacturing to component manufacturing and are a complement and/or alternative to conventional manufacturing technologies like metal forming.

The major advantage of additive manufacturing, i.e. the geometrical freedom of the components to be produced, is confronted with the big disadvantages of a long manufacturing time and the high energy consumption. In contrast to many forming technology processes, additive manufacturing processes are, despite machine and process-specific developments, still not suitable for mass production. Therefore, the Institute of Forming Technology and Lightweight Construction pursues the approach of an integration of additive manufacturing processes into the traditional forming technology in order to combine the advantages of both technologies. Currently, additively manufactured dies with inner cooling channels for the extension of the process limits during hot extrusion and additively manufactured tool windings for electromagnetic forming processes are explored at the institute.



Three manufacturing methods (additive, formative, and subtractive) integrated in one machine

Motivated by the previous research results, the „Research Group on Additive Technology" was established on August 1st, 2015. In this newly founded group the potential of the combination of additive and forming manufacturing processes shall be elaborated and explored fundamentally. A key factor for the facilitation of the research activities is an approved proposal for the acquisition of a combination machine for laser deposition of powder in a 5-axis machining center, which was installed at the end of the year. With this machine it will be possible to combine formative, additive, and even subtractive manufacturing processes for the first time in one machine. The IUL filed a patent for the process.

3.2 Coordinated Research Programs

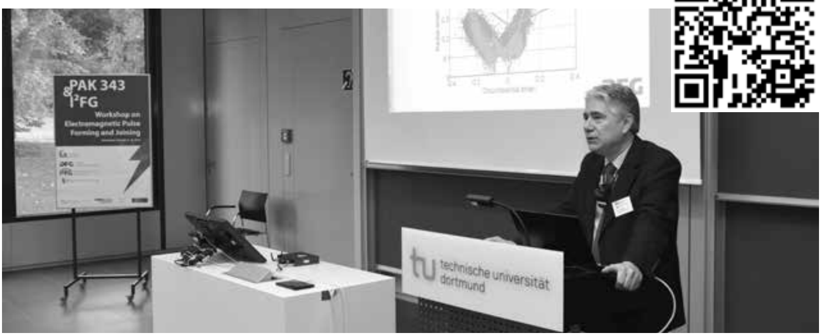
3.2.1 Combined Quasi-Static and Dynamic Forming Processes

Funding	Deutsche Forschungsgemeinschaft (DFG)
Project	PAK 343
Spokesman	Prof. Dr.-Ing. Dr.-Ing E.h. A. E. Tekkaya
Status	Completed

After six years of funding by the German Research Foundation (DFG), the joint project PAK 343 was successfully completed in September 2015. The main objective was the development of strategies for the design and the control of combined quasi-static and dynamic forming processes.

In the first funding period a combination of a deep drawing process with a subsequent electromagnetic forming operation in the cup radius region was investigated. In the second funding period several electromagnetic forming steps in the flange region were conducted parallel to the deep drawing process to increase the drawing ratio.

The PAK 343 Final Colloquium was organized within the international „Workshop on Electromagnetic Pulse Forming and Joining" on October 6, 2015. Representatives of the four involved research institutes presented their final results and the remaining challenges for the analyzed process combinations with focus on technology, numerical simulation, and materials science. The presentations of this Final Colloquium are available on the TU Dortmund University literature server (see QR-code).



Introduction by Prof. Tekkaya during the PAK 343 Final Colloquium on October 6, 2015

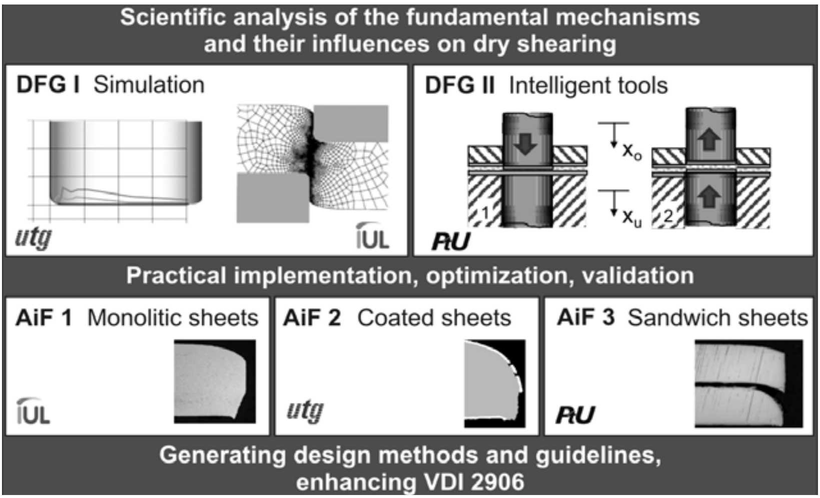
3.2.2 Dry Shear Cutting of Metal Laminated Composite Material

Funding	German Federation of Industrial Research Associations (AiF), German Research Foundation (DFG)
Project	PAK 678/0
Spokesman	Prof. Dr.-Ing. Dr.-Ing. E.h. A. E. Tekkaya

Laminated composite material offers many advantages for lightweight construction, especially due to the wide range of its properties. To facilitate the industrial application of such material in the future, important processing technologies need to be developed further. The development of the shear cutting technology is one of the main topics within this AiF/DFG-Cluster. The main objectives were to improve the process efficiency and to increase the capability of the process:

- Reliable control of the process
- Stability of the process concerning the part quality
- Avoid using additional lubricants
- Minimizing the tool wear
- Processing of new lightweight materials

The basic methodologies have been executed two DFG projects. The implementation in industry-related applications was carried out in three AiF projects. Participating research partners were PtU (Institute for Production Engineering and Forming Machines, Technische Universität Darmstadt) and utg (Institute of Metal Forming and Casting, Technische Universität München).

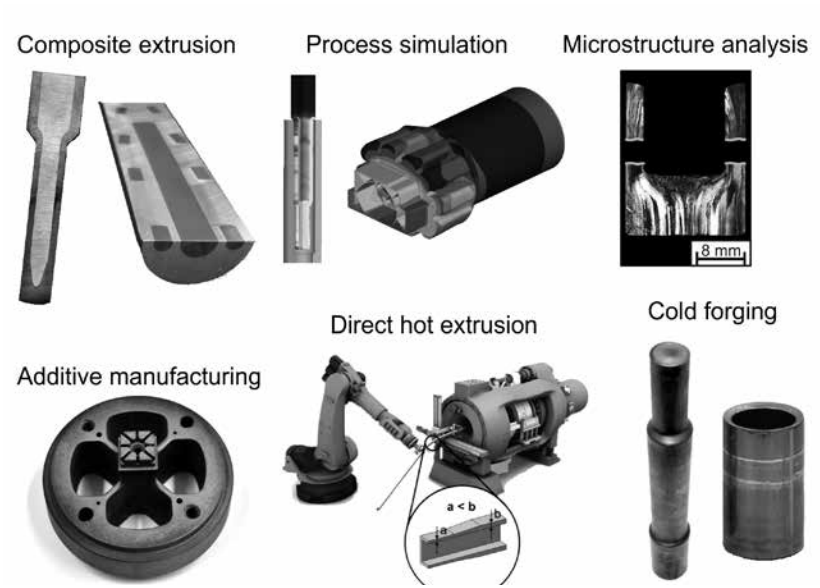


Methods and distribution of tasks in the AiF/DFG-Cluster

3.3 Department of Bulk Metal Forming

Head Dr.-Ing. Dipl.-Wirt.-Ing. Matthias Haase

The focus of research in the bulk metal forming department is on the development of innovative process variants of hot extrusion and cold extrusion. The scientific assistants work on the production of hybrid components, the gradation of the properties of the materials, and on taking the local mechanical properties for the dimensioning of lightweight components into account. The production of hybrid components is realized by the processes of composite hot and cold extrusion. Here, the mechanical and functional properties of the components are defined by combining lightweight materials with high-strength steel elements and functional elements. The gradation of the mechanical properties of a component can be achieved exemplarily by using multi-stage forging dies for the cold extrusion process. Therefore, the local mechanical properties at the surface of the cold-forged part can be defined. By using numerical simulations for the prediction of local mechanical properties and the subsequent dimensioning of lightweight components, the lightweight potential of these components can be exploited.

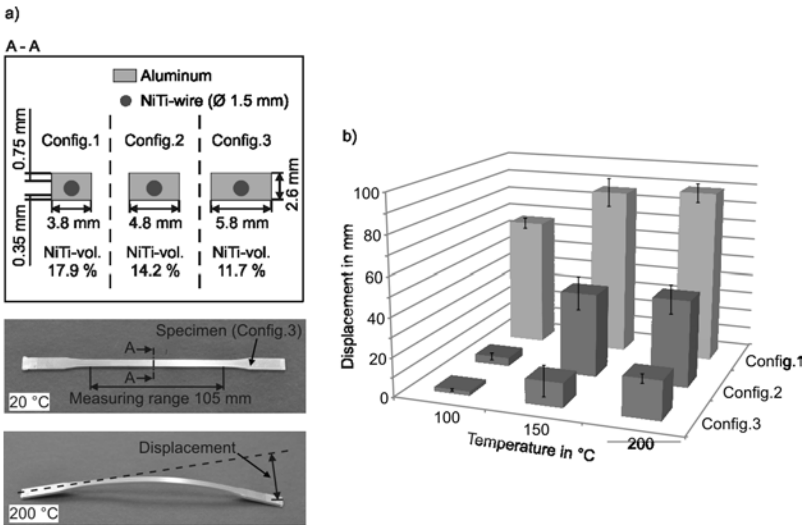


Overview of the research activities of the bulk metal forming department

3.3.1 Forming and Characterization of Actuator Profiles Based on Shape-Memory-Alloys

Funding German Research Foundation (DFG)
Project TE 508/45-1
Contact M.Sc. C. Dahnke

Shape memory metal matrix composites (SM-MMC) with an actuator function are produced in cooperation with the Institute of Applied Materials of the Karlsruhe Institute of Technology (KIT) by means of composite extrusion and further forming processes. The mechanical and technological funda-mentals of this approach are analyzed. By using composite extrusion, NiTi-wires are continuously embedded into an aluminum matrix. After the manu-facturing process a defined axial elongation is induced into the structural components. The shape memory effect is activated due to a subsequent heat treatment in which the specimens are heated above the characteristic austenite finish temperature of the NiTi-elements. Thereby, the contraction of the wires within the specimens as well as their eccentric positioning creates a deformation of the component. In order to achieve a defined de-flection of the components, the knowledge of all influencing parameters is absolutely necessary. In consideration of different specimen geometries (figure a), recent studies show that the temperature and especially the NiTi-volume as well as the position of the wire have a significant influence on the achievable deflection (figure b).

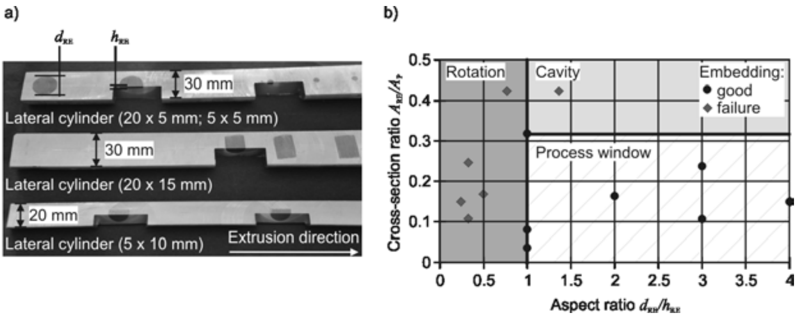


a) Investigated specimen geometries and influence of the heat treatment, b) Influence of the temperature and the NiTi-volume on the achieved deflection

3.3.2 Optimization of Workpieces by Forging of Composite Aluminum Extrudates

Funding German Research Foundation (DFG)
Project TE 508/17-2
Contact Dr.-Ing. Dipl.-Wirt.-Ing. M. Haase

Hybrid structural components are manufactured in the process chain "Discontinuous composite extrusion and subsequent forging" in cooperation with the IFUM Hannover. With respect to the composite extrusion process, especially the embedding of centrically or eccentrically positioned, rotationally symmetric reinforcing elements in an aluminum matrix has been investigated up to now. Thereby, the quality of the embedding is evaluated by means of three characteristic process defects: rotation and local plastic deformation of the elements as well as the development of cavities in front of the elements. In recent studies was shown that also non-rotationally symmetric elements as well as elements, which are positioned laterally to the extrusion direction, could be embedded in the aluminum matrix without any defects (figure a). Subsequently, the achieved experimental results have been converted into a process window (figure b). The expansion of the process leads to a significant increase of the flexibility, in particular with regard to a potential industrial application of the investigated process chain.

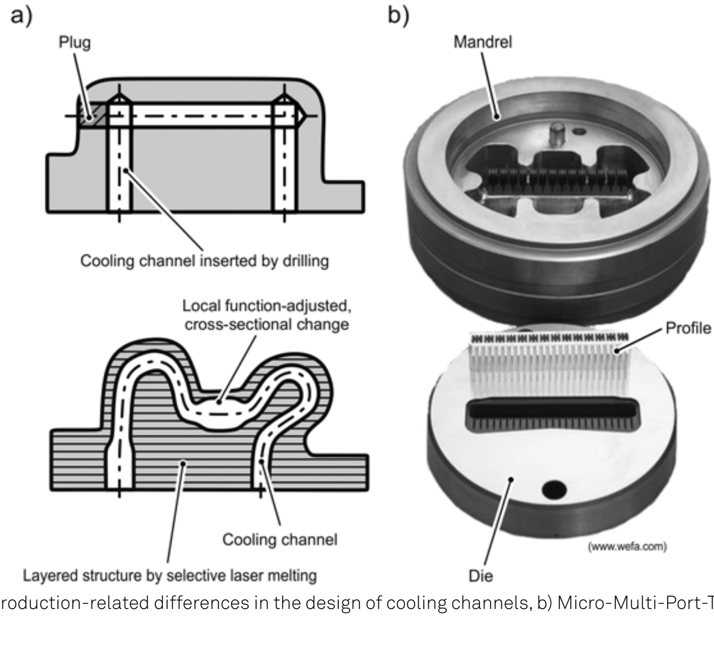


a) Results of the experimental investigations (lateral cylinder (d_{RE}×h_{RE})), b) Process window for the embedding of cylinders positioned laterally to the extrusion direction

3.3.3 Complex Industrial Extrusion Dies with an Integrated Die Cooling

Funding	BMWi/ZIM-KF
Project	KF2198142KO4
Contact	M.Sc. O. Hering

The extrusion speed of profiles can be increased by up to 80% by using hot extrusion dies with integrated cooling channels. The position of the cooling channels and the cooling strategy have a major impact on the achievable profile exit speed and, thus, also on the surface properties of the produced profiles. In conventionally manufactured extrusion dies it is only possible to insert simple cooling channels, e.g. straight boreholes, due to manufacturing constraints (Fig. a), top). In this collaborative project with the company WEFA Inotec GmbH extrusion dies with complex conformal cooling channels are realized in industrial extrusion dies (Fig. a), bottom). Here, selective laser melting is used as the manufacturing process in order to produce complex Micro-Multi-Port-Tools (Fig. b)) with integrated cooling channels for producing heat exchangers. The tools are to be evaluated by experimental and numerical investigations regarding the achievable profile quality and productivity.

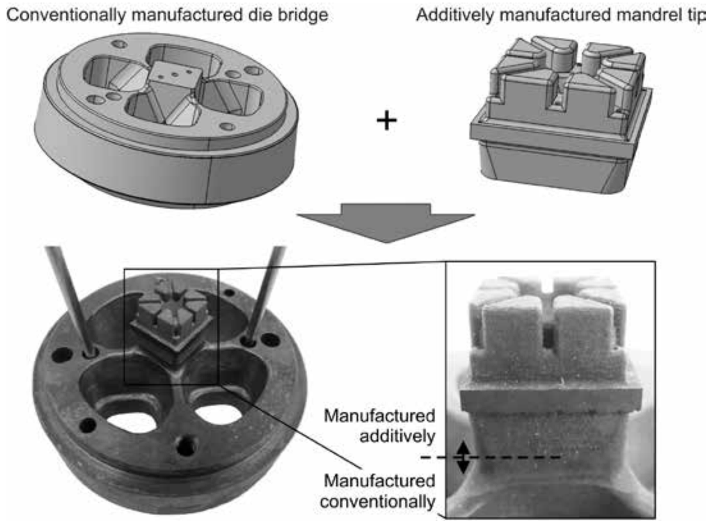


a) Production-related differences in the design of cooling channels, b) Micro-Multi-Port-Tool

3.3.4 Extrusion Dies with Local Internal Cooling Channels Manufactured by Additive Manufacturing Technologies for Extending the Process Limits in Hot Extrusion

Funding	German Research Foundation (DFG)
Project	TE 508/27-2
Contact	Dr.-Ing. Dipl.-Wirt.-Ing. R. Hölker-Jäger
Status	Completed

The application of the inner die cooling in hot extrusion leads to a significant increase of the production speed. By localizing the cooling in the area close to the forming zone, the extrusion force increases only moderately. For the technological implementation of the local inner die cooling, two additive manufacturing processes were used: The layer-laminated manufacturing method, where tool parts are assembled by single sheet layers, and the selective laser melting, where geometrically complex parts are built from steel powder. Furthermore, a hybrid die concept was developed and tested experimentally. Here, the geometrically simple die part with a large volume, like the die bridge, was manufactured conventionally by subtractive methods. The smaller part with a complex geometry, like the top of the mandrel, was added on it by selective laser melting (see figure). The experimental results show that these hybrid tools withstand the high mechanical and thermal loads which occur during hot aluminum extrusion.

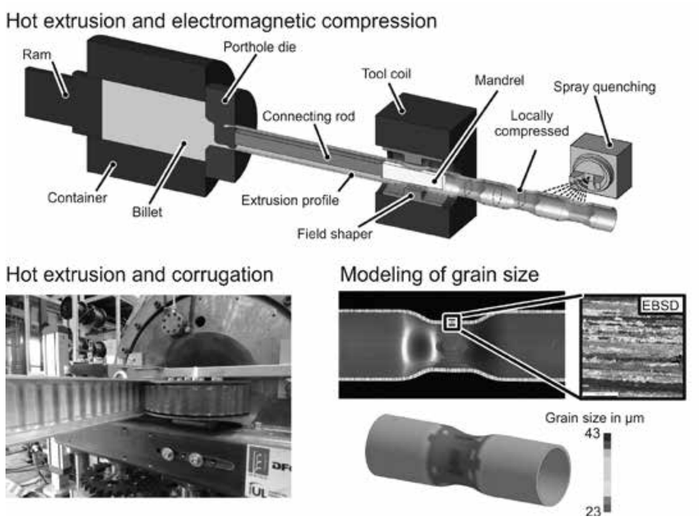


Concept for a hybrid mandrel (top) and real manufactured hybrid mandrel with a detail view of the mandrel tip (bottom)

3.3.5 Thermo-Mechanical Processing of Aluminum Alloys Subsequent to Extrusion

Funding	German Research Foundation (DFG)
Project	SFB/TR 30 • Subproject A2
Contact	Dr.-Ing. Dipl.-Wirt.-Ing. M. Haase
Status	Completed

In this research project the production of parts with locally adapted properties by integrating thermo-mechanical forming and heat treatment operations into the process of direct hot extrusion was investigated. The focus of the project was on the numerical process design and on the technological development of the process chain "Electromagnetic compression and local heat treatment". Furthermore, the process combination of hot extrusion and corrugation was developed for the production of corrugated I-beams, which have an increased load capacity compared to conventional I-beams. For the analysis of the developed process chains thermo-mechanically coupled numerical simulations were conducted along the whole process chain, using the results of one process step as an input variable for the next step. In addition, a model for the prediction of the local grain size was also developed and integrated into the numerical simulation, which allowed a correlation of the individual process parameters to the resulting microstructure in the produced parts.

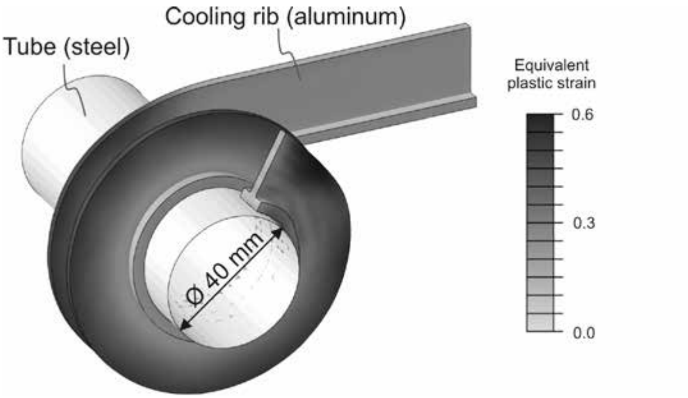


Developed process chains and model for the prediction of the grain size

3.3.6 Ribbed Tubes by Hot Extrusion

Funding	ZIM
Project	KF2198117RU2
Contact	Dr.-Ing. T. Kloppenborg
Status	Completed

Ribbed tubes serve as heat dissipator by leading a corrosive cooling fluid through a chemically resistant steel tube. Cooling ribs made of a material with a high thermal conductivity dissipate the heat to the environment. A process for the cost-efficient manufacturing of ribbed tubes made of different materials was developed for an industrial partner at the IUL. A hot extruded aluminum profile is being coiled onto a tube directly after exiting the die. The temperature of the profile behind the die orifice is about 400 °C. By cooling down, the cooling ribs shrink onto the tube, which results in a press-fit between the ribs and the tube. Different geometries of the cooling ribs were analyzed experimentally as well as numerically (see figure). Abaqus 6.13 was used for the numerical analyses with an explicit solver.

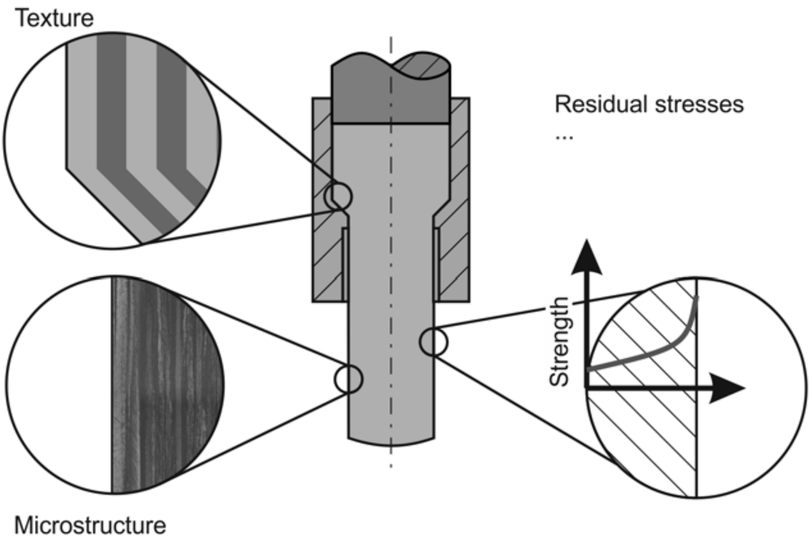


Simulation of the coiling process after hot extrusion of an aluminum T-profile

3.3.7 Prediction of Local Product Properties in FEM Forming Simulations

Funding	AiF/Fosta
Project	18225 N/P1057
Contact	Dipl.-Ing. M. Schwane

In the subproject TP3, which is a part of the project "Massive Lightweight Construction", local product properties shall be specifically exploited and considered in order to obtain a weight reduction of cold forged components. For this, the IUL and the Institute of Machining Technology (ISF) of the TU Dortmund University as well as the Institute for Metal Forming Technology (IFU) of the University of Stuttgart collaborate closely.
At the IUL, material models for finite element simulations are selected, examined, and qualified to permit the precise prediction of product properties, such as strength and residual stresses (see figure), which result from the forming process. The simulation results are verified by means of benchmark experiments and in-depth component testing. The determined material models and material data will be used in the forming simulation, in the subsequent machining simulation (ISF), and finally in the structural simulation (IFU). The integrated simulation is supposed to allow a load adapted component design and, hence, the exploitation of the lightweight potential of cold forged components.

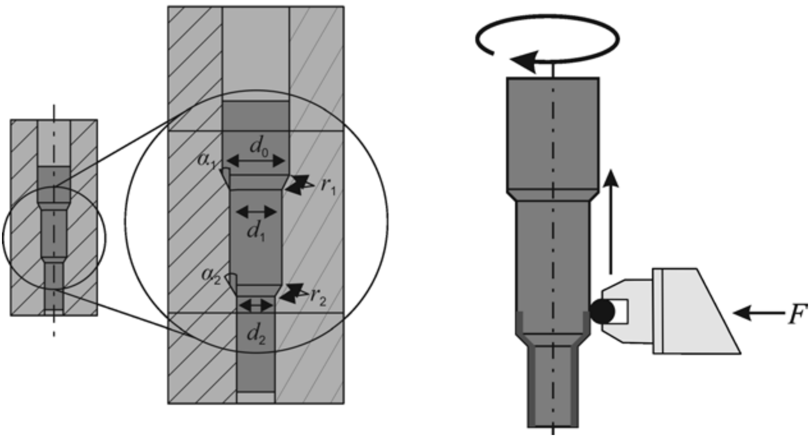


Product properties of cold-forged components

3.3.8 Extended Technological Limits of Bulk Forming Processes in Different Temperature Ranges

Funding	AiF/Fosta
Project	18229 N/P1058
Contact	M.Sc. O. Napierala

In this joint project of the research initiative "Massiver Leichtbau" a gear shaft with load-adapted mechanical properties, especially a high surface hardness and strength at the peripheral zone, is produced in cooperation with the IFU Stuttgart and the IFUM Hannover by means of forming processes. The aim of this project is to maximize the effect of work hardening in the peripheral zone to reduce the vehicle weight by a load-adapted dimensioning of the components. Both the influence of the process chain, for example single or multistage cold extrusion, the variation in die geometry (see figure a), e.g. the cone angle α, and also the influence of the tribological conditions on the mechanical properties are investigated numerically and experimentally. Subsequently, it will be determined how a deep rolling process can replace a traditional heat treatment to increase the hardness of the peripheral zone (see figure b). It is also investigated whether an already hardened shaft surface can be further strengthened by an additional deep rolling process.

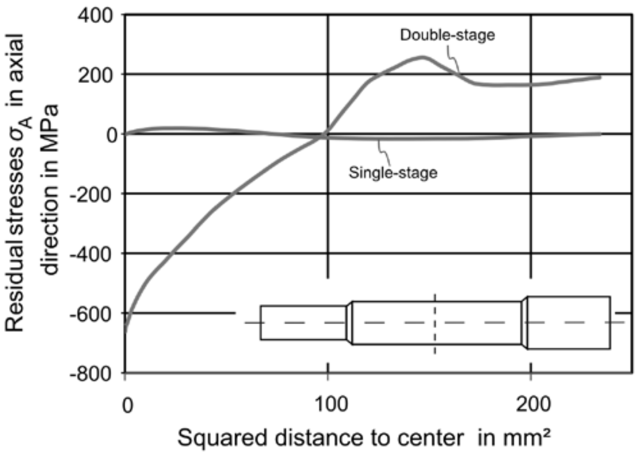


a) Parameters of the cold extrusion die, b) Surface hardening of a shaft by deep rolling

3.3.9 Systematic Process Control in Cold Forging and Heat Treatment for Minimizing Distortion

Funding	AiF ZUTECH
Project	478 ZN
Contact	Dipl.-Ing. S. Ossenkemper

Cold forged parts can show size and shape deviations after a subsequent heat treatment due to the release of residual stresses. Reducing this distortion by a systematical adaption of the process parameters is the aim of this research project which is performed in cooperation with the Foundation Institute of Materials Science (IWT), Bremen. To analyze e.g. the influence of the manufacturing route on the distortion, gear shafts were manufactured in different ways. Besides a single-stage cold forging operation, shafts were double-stage cold-forged and also machined for comparison purposes.
Numerical analyses show that the manufacturing route strongly affects the residual stress distribution. In double-stage forging the middle step of the shaft shows high compressive residual stresses in the core and tensile residual stresses near the surface, while in case of single-stage cold forging the residual stresses are significantly lower (see figure). Due to the release of residual stresses during heating, the shafts show a different distortion behavior.

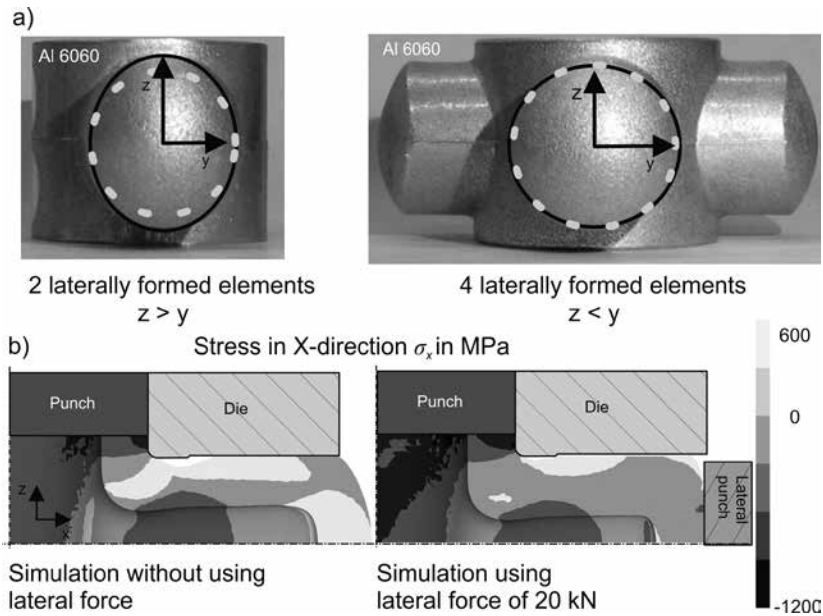


Numerically determined residual stresses in axial direction in the middle step after ejecting for single and double-stage cold forging

3.3.10 Hollow Lateral Extrusion of Additional Shape Elements

Funding	German Research Foundation (DFG)
Project	TE 508/13-3
Contact	M.Sc. O. Napierala
Status	Completed

Within the scope of this joint project of the IUL and the Institute for Metal Forming Technology of the University of Stuttgart the basics of the manufacturing process “Hollow lateral extrusion without lateral mandrel” were developed. The observed geometric effects of wall thickening as well as the conical and elliptical shape of the lateral elements (see figure a) could be analyzed and explained by numerical experiments. The conical and elliptical shape could be avoided by the use of lateral punches and by improving the die geometry. Furthermore, the use of lateral punches led to a superposition of compressive stress. The tensile stresses near the surface of the samples (see figure b) could be minimized, which can potentially improve the lifetime of the component. The gained knowledge of this manufacturing process is also used for the production of a flange by using Hollow Lateral Extrusion. The created process window for manufacturing the flange could also be enhanced by the use of lateral punches.



a) Samples with 2 and 4 laterally formed elements, b) Stress σx with and without the use of a lateral punch

3.4 Department of Sheet Metal Forming

Head Dr.-Ing. Alper Güner

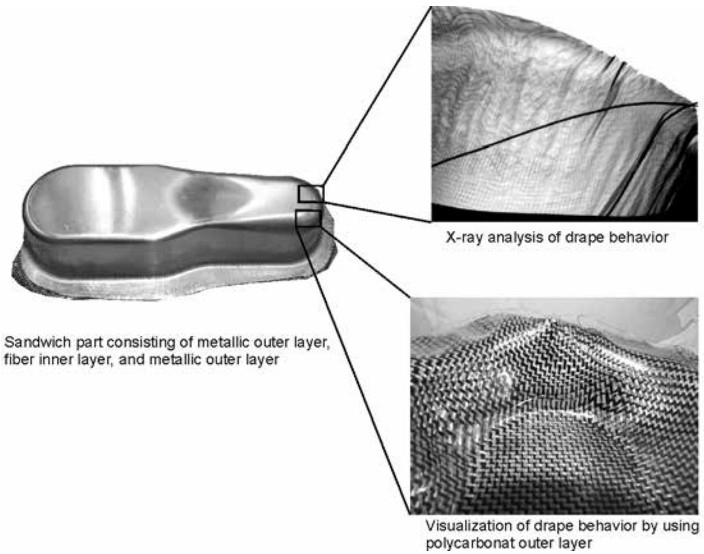
The department of sheet metal forming is primarily concerned with the analysis and development of both known and new sheet metal forming processes and characterization of utilized sheet materials. The primary goal is to enhance the understanding of physical relations, so as to develop sustainable technologies and to end up with efficient process designs. In 2015, the department's activities, especially in the field of hybrid structures, were presented at the Euromold fair in Düsseldorf. Other highlights of the year were the leading market competitions within the framework of the EFRE.NRW programs. Here, the group could place two winning projects in the field of magnesium-plastics-hybrid structures and online process monitoring in press hardening. This year, the sheet metal forming department welcomed two guest scientists from Harbin Institute of Technology in China (for one year) and JFE Steel in Japan (for two years), who will do research in various fields at the IUL.

Exhibition stand at the Euromold 2015 in Düsseldorf

3.4.1 In-Situ Hybridization of Sandwich Sheets

Funding German Research Foundation (DFG)
Project BE 5196/4-1
Contact Dipl.-Ing. T. Mennecart

In this project lightweight components are intended to be manufactured in a one-step process. These sandwich sheets consist of metallic outer layers and an inner layer consisting of fiber-reinforced thermoplastic (see figure below). In cooperation with the Karlsruhe Institute of Technology (KIT), the two processes of deep drawing and resin transfer molding will be combined. The forming process starts with a wrought material stacked by metallic sheet, dry fibers, and metallic sheet. This stack is formed and during the forming process two monomers are injected through the fiber. During the injection a chemical reaction occurs which leads to a polymerization. The curing takes place in the closed press at elevated temperatures. Designated target is the adjustment of a process window in which the parts show no failure and the bonding between sheets and fibers can withstand high loads. Investigations at the IUL will deal with the formability of multi-layer sheets under the influence of the viscosity and the different loads applied.

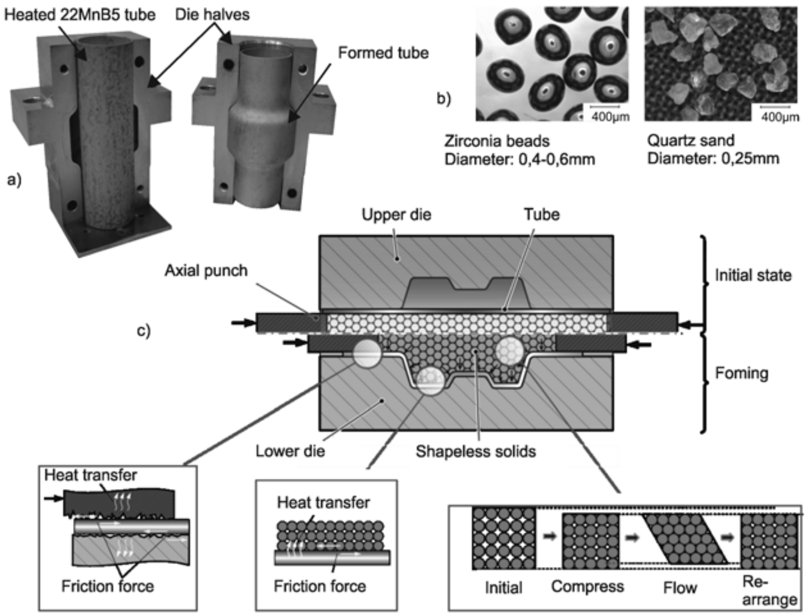


Sandwich sheet with fiber reinforcement

3.4.2 Granular Media-Based Tube Press Hardening

Funding	German Research Foundation (DFG)
Project	TE 508/52-1
Contact	M.Sc. S. Hess

Press hardening of closed profiles is an excellent possibility for the manufacturing of components with very high stiffness and strength. In this project granular material is used as forming media because conventional fluids used as forming media in hydroforming are not suitable for the application in press hardening. For the application of shapeless solids investigations regarding the mechanical behavior of the particles under high pressure conditions are necessary. The surface nature of an individual particle as well as the packing structure of a particle volume have direct influence on the pressure distribution within the forming zone. Additionally, the shape of the punches can optimize the force transmission from axial in radial direction. The project is geared for the collaboration with the German Aerospace Center (DLR) in Cologne. In close cooperation, the physical processes within the granular media, which are initiated by the pressurization, are studied and described.

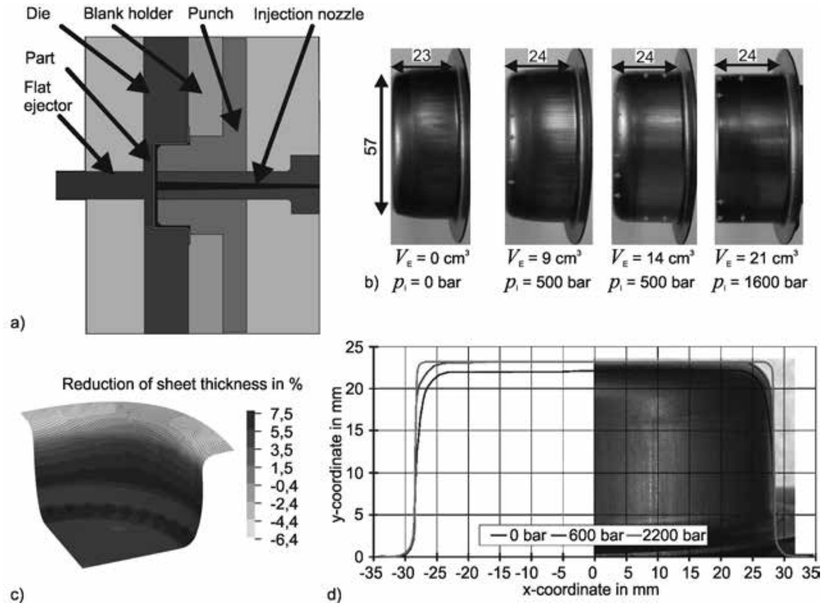


a) Tool, b) Granular media, c) Interaction between granular media and tube during press hardening

3.4.3 Production of Structural Elements by Deep Drawing and Back Injection in Injection Moulds

Funding AiF
Project 18075 N
Contact Dr.-Ing. A. Güner

The aim of this project is the development of a combinated process for the production of hybrid lightweight components with structural application made out of steel and polyamid. For this, tools for deep drawing are integrated into an injection-molding tool so that a part can be formed and injected back within one manufacturing step. Through experimental investigations the influence of the injection volume and holding pressure was identified. A suitable lubricant was determined that can chemically withstand the bonding agent as well as the polyamide. For the analysis of adhesion samples were pre-stretched in uniaxial direction and then back-injected in a separate step. Compared to tool temperatures of 80 °C, the strength of the bonding can be raised using tool temperatures of 120 °C. By numerical calculations of the deep drawing process the critical regions of the part were identified. Those are the areas with the highest thickness reduction which can be found at the radius of the bottom and in the flange region (as shown in the figure below).

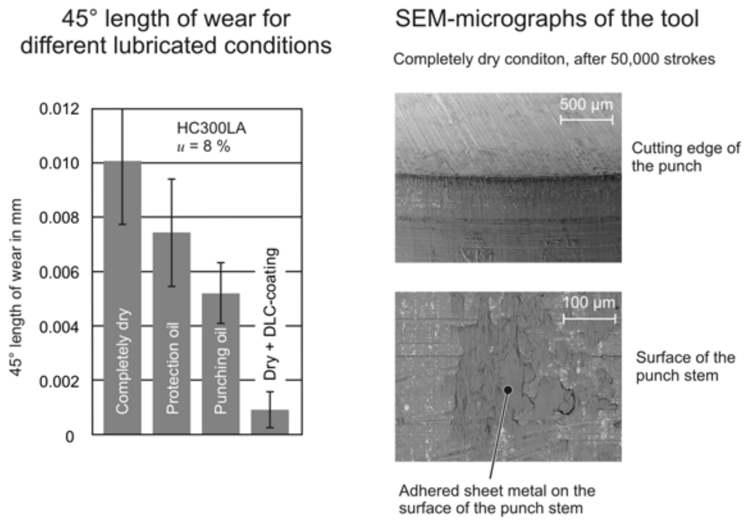


a) Tool, b) Fill study, c) Critical regions of the component, d) Influence of holding pressure on forming operation

3.4.4 Dry Shearing of Metal Material and Polymers

Funding AiF/Fosta
Project 17791 N/P 885
Contact Dipl.-Ing. F. Steinbach
Status Completed

This project is part of the DFG/AiF-Cluster "Dry Shearing". The challenges which dry shearing implies are examined in the project. For typical speeds of shearing, e.g. like in the production of automotive sheet metal parts, no significant influence regarding cut edge surface and shearing forces could be found between cuts under dry and oiled condition.
On the other hand, the wear of the shearing tools is substantially affected. By comparison of different oiling conditions in a long-term test, the highest wear was measured for the dry condition, as expected (see figure). However, the protection oil which is applied in the manufacturing of sheets (as delivered) could already reduce the tool wear. Here, the decreasing effect of lubricants on adhesion acts positively. Especially the use of novel DLC-coatings of the shearing tools needs to be mentioned. The high hardness of the coating and the minor tendency of cold welding results in a considerably increased life time of the shearing tools.

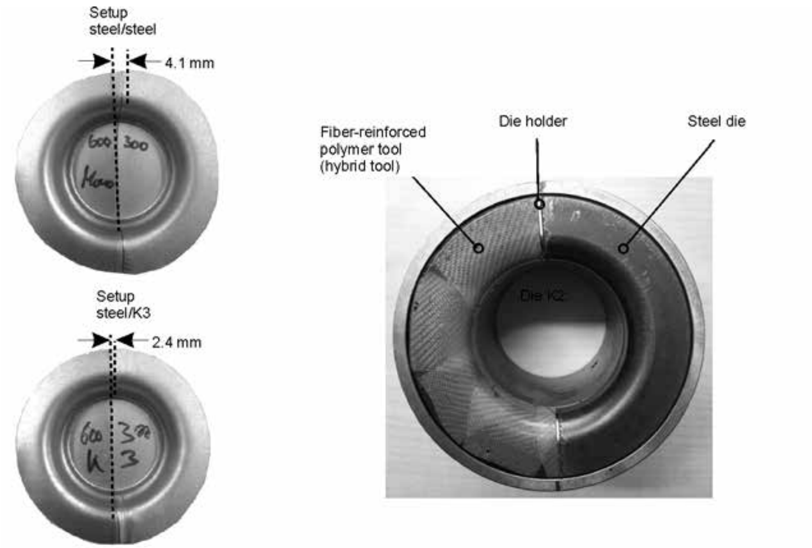


Comparison of tool wear and SEM-micrographs of the cutting edge

3.4.5 Hybrid Deep Drawing Tools of High Wear Resistance with an Adaptive Tool Stiffness

Funding	German Research Foundation (DFG)
Project	SFB 708 • Subproject C1
Contact	Dipl.-Ing. T. Mennecart
Status	Completed

In this project hybrid deep drawing tools were produced and their performance as a tool material could be proved. These tools are made of a polymer body and a fiber reinforcement as a coating to minimize the deformation under applied loads. It could be shown that high-strength steels as DP600 can be formed successfully. Furthermore, life cycle tests were performed to show the capability of the use in mid production ranges. Further investigations dealt with the possibility of influencing the blankholder pressure by the use of functional elements like springs or actuators in the polymer body. The results showed that the material flow can be optimized in order to improve the geometrical accuracy of the formed parts when the load is changed locally and temporally. Finally, the use of tailored tools, combining hybrid and steel tools, showed improvements in the formability of high-strength tailor welded blanks (as shown in the figure below).

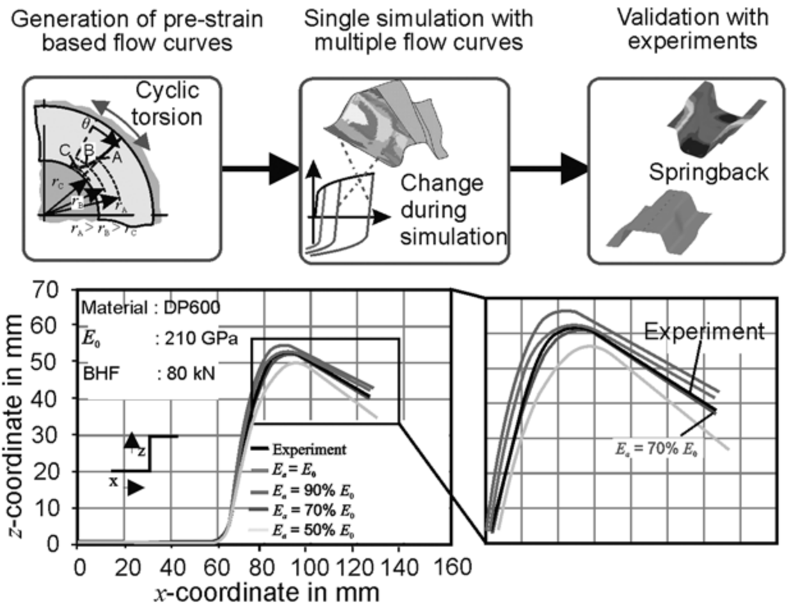


Use of tailored tools (hybrid/steel) for the forming of tailor welded blanks

3.4.6 Strategies for Springback Compensation

Funding German Research Foundation (DFG)
Project SFB 708 • Subproject C3
Contact M.Sc. H. ul Hassan

The aim of this project is to allow for an optimal and robust layout of deep drawing and stretch drawing processes with respect to dimensional accuracy and part failures. An enhanced finite element model is generated which is capable of the variation of process parameters as the blankholder force over the process time. The model can also accommodate the pre-strain based material parameters for different kinematic hardening models. This implementation has made it possible to improve the accuracy of springback prediction and to reduce it in deep drawing processes.
In the recent investigations the effect of Young's modulus degradation on springback prediction (as shown in the figure) and reduction is analyzed for DC04, DP600, and DP1000 materials. The degradation is 28 % and 26 % for DP600 and DP1000 and 14 % for DC04 at their saturation level. It is observed that the springback can be reduced if the maximum force is used only during the last 13 % of the punch travel. Higher tension at the end of deep drawing leads to the same residual stresses. However, the reduction in Young's modulus is smaller, which leads to smaller springback.

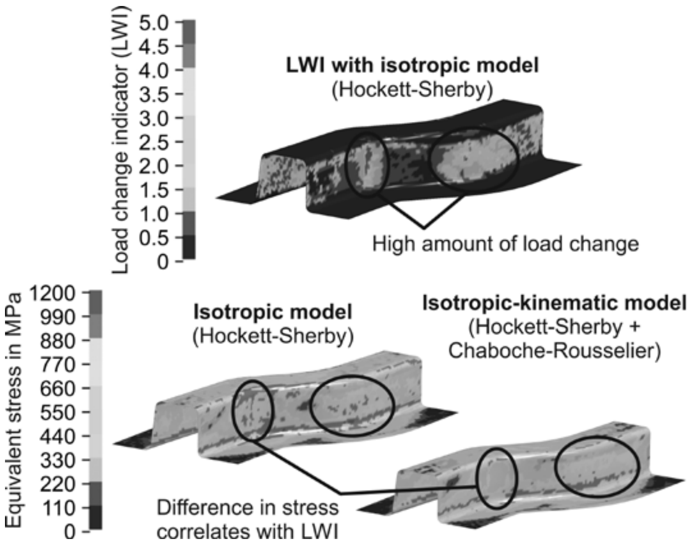


Springback prediction based on multiple stress strain curves and influence of Young's modulus degradation

3.4.7 Identification of Stress-Dependent Bauschinger Coefficients

Funding	EFB/AiF
Project	17375N/1
Contact	M.Sc. H. Traphöner
Status	Completed

This project is carried out in cooperation with the Institute of Manufacturing Technology in Erlangen and industrial project partners. At the center of the project was the analysis and comparison of different methods to characterize the kinematic hardening and the identification of characteristic values for different complex isotropic-kinematic hardening models. The requirement of complex modeling approaches has been tested for three materials and an less elaborate and more accurate modeling of kinematic hardening has been determined. A new tool for a preliminary evaluation of the need for different complex numerical hardening models was developed in the form of a scalar load change indicator (LWI), which has been implemented for LS-Dyna. It was tested in a S-rail workpiece as seen in the top of the figure. LWI provided an estimation of local stress differences within a component. The aim of this aproach was the assessment of the modeling effort based on isotropic material models, only with the evaluation of occuring local deformation changes (bottom of figure).

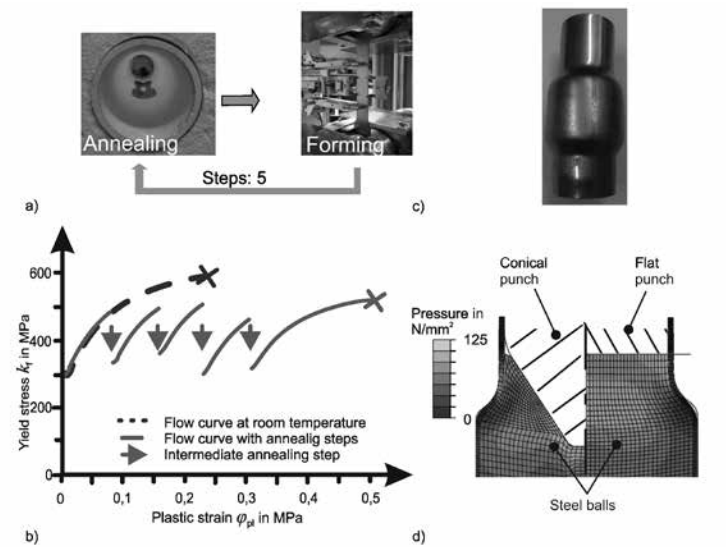


Application of the load change indicator (LWI) for an „S-rail“ tool

3.4.8 Extension of the Formability by Using Heat within the Process Chain

Funding ReCIMP
Contact M.Sc. S. Hess

The focus of this project is the extension of the forming capacity of ferritic stainless steel. A reliable manufacturing process for components with hydroformed shapes shall be enabled using targeted heat treatment (see figure). The first approach is to include intermediate annealing steps between the forming steps. With a standard tensile test it is shown that the value of true strain can be doubled using suitable annealing parameters.
Another approach is to use heat treatment during the forming step. Superficially, a process similar to hydroforming is examined, but instead of using liquids, shapeless solids like steel balls are used as forming medium. Due to the heating the material is softened during the hot forming step so that the forces necessary to form the material are reduced. Furthermore, the punch geometry shows a direct influence on the material flow. If flat punches are used, the transmission of the axial forces towards the radial direction takes place through the contact surfaces within the granular material. Using conical punches, the transmission is additionally assisted by the punch geometry itself.

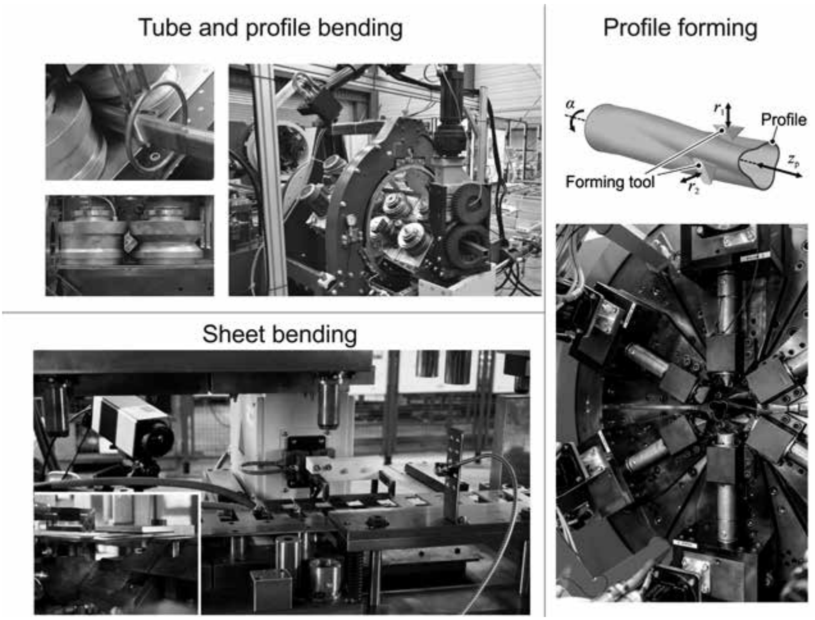


a) Scheme, b) Intermediate annealing: results, c) Forming with steel balls, d) FEM: Influence of punch geometryl

3.5 Department of Bending Technology

Head Dr.-Ing. Christoph Becker (until October 31, 2015)
M.Sc. Lars Hiegemann (since November 1, 2015)

Tube and profile bending, sheet bending, and profile forming are the main research areas of the bending department. In the field of tube and profile bending the focus is on the investigation of kinematic 3D bending processes to improve their accuracy as well as the flexibility of bending processes in general. Furthermore, the process limits can be expanded and the bending forces can be decreased by a combination of the bending process with other forming processes like flow forming. In addition, research is carried out to increase process limits and develop an improved process understanding for sheet bending processes. These increased process limits are achieved by a hot air bending process combined with active control and setting of process parameters. Furthermore, investigations for the design of roll forming processes are carried out. In the field of profile forming current research is done to investigate incremental forming processes. By this, profiles with high geometric flexibility can be produced. This approach was awarded the Steel Innovation Prize in 2015.

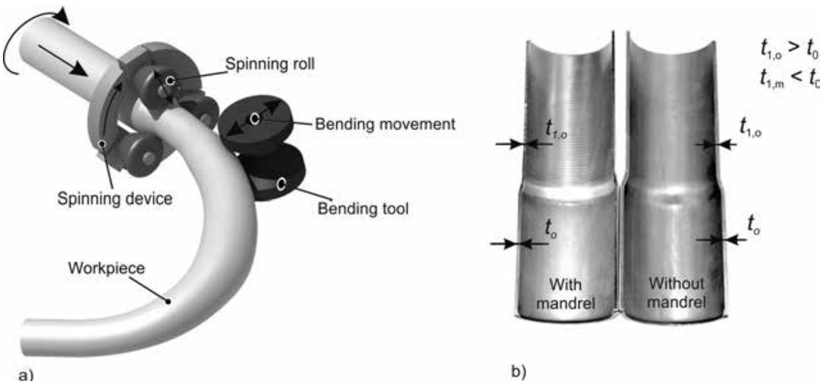


Research areas of the bending department

3.5.1 Incremental Tube Forming to Establish a Process Model in Order to Predict Springback

Funding	German Research Foundation (DFG)
Project	TE 508/26-2
Contact	M.Sc. E. Nazari

Incremental tube forming (ITF) is a process in which free form tube bending and spinning are combined, as shown in figure a. This combination results in a reduced bending force as well as a reduced springback compared to conventional tube bending processes. In the first phase of the project bending of the tubes with constant diameter reduction has been investigated. Furthermore, a process model which is able to predict the bending moment and the springback quiet accurately has been developed.
In the second phase of the project the possibility of wall thickness adjustment is investigated. For this reason, an internal mandrel is used. It can be seen that during the incremental tube forming process without using the mandrel the thickness increases unintentionally. However, it is possible to achieve the desired wall thickness by using the mandrel and adjusting the clearance between the inner mandrel and the spinning roller (see figure b). Furthermore, the whole process will be analyzed with experimental as well as numerical and analytical approaches.

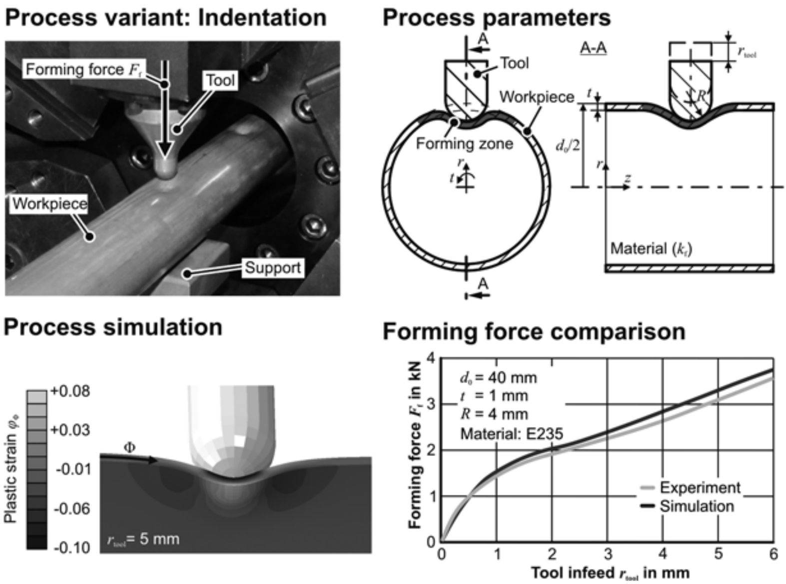


a) Process principle of incremental tube forming, b) Comparison of the wall thickness with and without internal mandrel

3.5.2 Fundamentals of the Incremental Profile Forming

Funding	German Research Foundation (DFG)
Project	BE 5196/3-1
Contact	Dipl.-Ing. G. Grzancic

Incremental profile forming is an innovative process for the flexible manufacturing of tubes and profiles with changing cross-section geometries along the longitudinal axis. In order to deploy the process effectively, the physical basics will be developed within this research project. On the one hand, process knowledge will be gained by fundamental research and significant process parameters will be quantified. On this basis, process limits and suitable process windows will be defined. On the other hand, process limits will be extended by the introduction of superposed oscillations into the forming process. Since the dynamic change of contact conditions leads to a modification of the friction behavior, the process forces will be reduced.
The figure provides the results of the first experimental and numerical investigations regarding the tube indentation step by which forming mechanisms (stress and strain conditions) are identified and forming forces are determined.

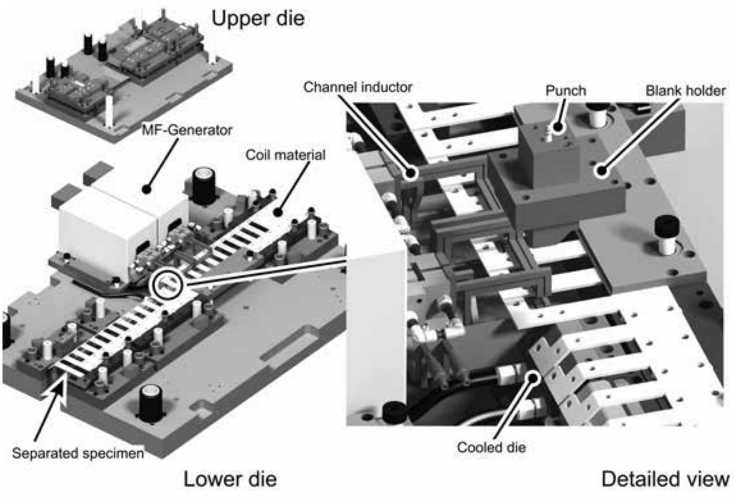


Indentation studies in Incremental Profile Forming

3.5.3 Indubend – Technology for Inductive In-Situ-Heating in Stamp- and Bend Forming with Progressive-Press-Tools

Funding	BMWi/ZIM-KF
Project	KF2198118LK2
Contact	M.Sc. C. Löbbe
Status	Completed

In the Indubend project a technology for warm forming in progressive press tools was developed in cooperation with the company KODA in order to reduce springback of high-strength steels. For the process demonstration and the theoretical analysis a progressive prototype die has been developed, which is shown in the figure. Based on this prototype, the warm bending of a micro-alloyed steel was investigated for high stroke rates up to 20 min-1. The picture shows the upper and lower die. Modular units for inductive heating, forming, cooling, and stamping before and after forming are integrated to cover a wide range of process variations. Based on the prototype tool and the integrated acquiring systems as the force and temperature sensors, a fundamental process knowledge has been obtained. Through the new warm bending technology general problems as e.g. the high stamping forces and low accuracy when stamping high strength steels can be compensated. Furthermore, by the additional heat higher geometrical flexibility due to the higher formability and adapted residual stresses will also be achieved.

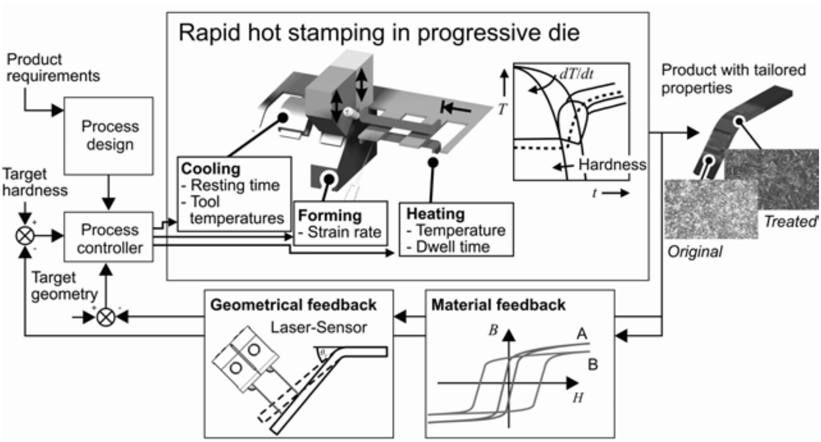


Upper and lower die of progressive press tool and detailed view of heating and forming station

3.5.4 ConProBend – Closed Loop Control of Product Properties in Progressive Dies

Funding BMWi/ZIM-KF
Project KF2198138LP4
Contact M.Sc. L. Hiegemann

In the ConProBend project a technology for the adjustment of geometrical and mechanical properties in progressive dies will be developed in cooperation with the company KODA by means of a combined heat treatment and forming operation. In compliance with a standard hot forming process, the integrated heat treatment, which consists of a rapid heating, forming, and quenching, offers the opportunity to shape material parameters beyond the geometrical dimension. As shown in the figure, the centerpiece within this development is the closed loop control based on the online feedback of both geometrical and strength properties. In order to adapt the target values, a multi-variable control system will be implemented, controlling several process parameters as the dwell time at high temperature, the forming speed, the resting time in the lower tool point, and tool temperatures at the same time. In addition to the multi-variable control system, the project focuses on the development of an intelligent technology to increase the cooling effect and control plastic forming through thermal strains.

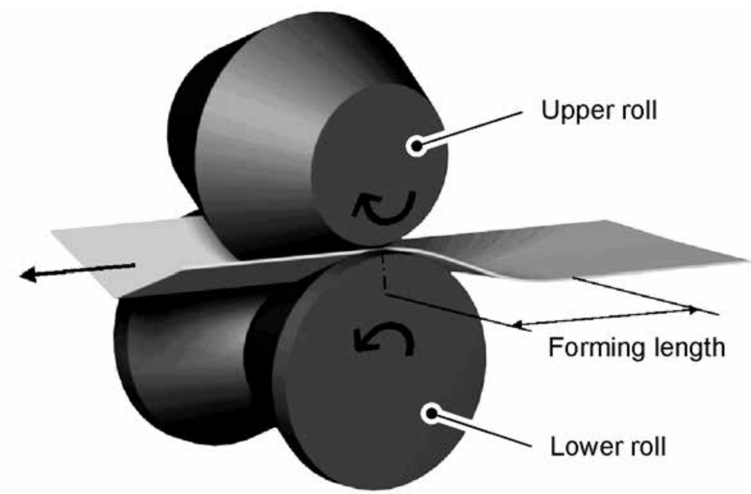


Closed loop control of product shape and properties in a progressive die

3.5.5 Material Behavior in Roll Forming Processes

Funding Cooperative project with ThyssenKrupp Steel Europe AG
Contact M.Sc. M. Tschierschke

In roll forming processes sheet metal is formed to a desired shape in several consecutive steps. Besides transverse bending shear, longitudinal bending and stretching occur in roll forming. Simplified assumptions are often made on the basis of existing models to describe the roll forming process. Alternatively, the models are based purely on empirical data. High-strength steels are increasingly used in roll forming, but the existing models cannot describe the material behavior satisfactorily. The project is realized in cooperation with the ThyssenKrupp Steel Europe AG and the project's objective is to gain a better understanding of the process. For this purpose, experimental investigations will be carried out. Furthermore, a numerical model is implemented to undertake simulations of the roll forming process. Analytical models will be developed to describe process parameters, such as the forming length (see figure). A comparison of the roll forming process with other bending operations such as swing bending is also of interest. The comparison is used to describe the bending behavior and failure of different bending operations.

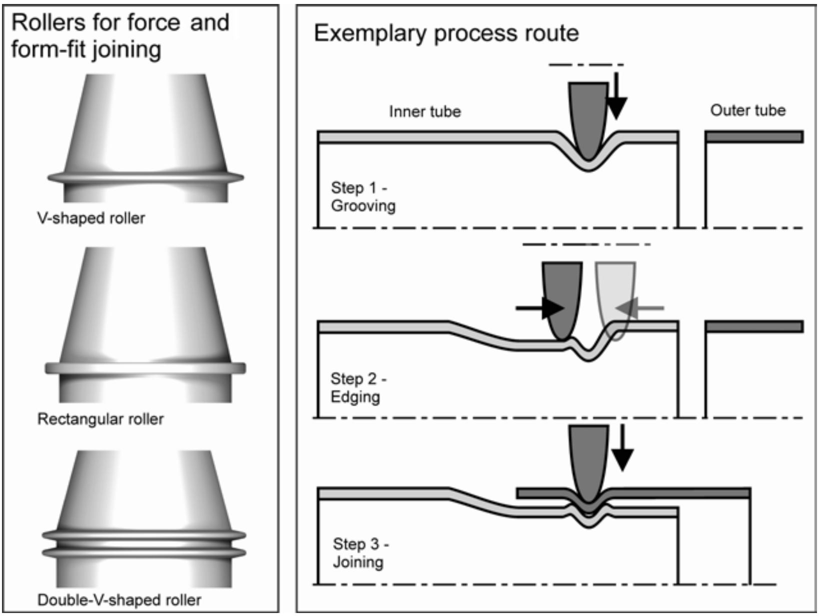


Roll forming of a V-shape

3.5.6 Mechanical Joining of Tubes by Incremental Tube Forming

Funding ReCIMP
Contact M.Sc. C. Löbbe

In the project the mandrel-free spinning process to produce form and force-fit joints out of congeneric tubes is investigated. Based on an experimental analysis of different process routes, several demonstrators are manufactured which will finally be tested in a mechanical and thermal examination. To reveal the strength of force-fit joints, parameters such as the revolution/feeding ratio, the diameter reduction ratio, and the roller radius are alternated for different steel grades and tube thicknesses. The form-fit joints are analyzed with respect to the motion sequence in order to achieve notches and grooves with sharp edges, which should enhance the joint strength. Finally, in mechanical tests the tensile and bending strength is measured as well as the tightness and durability during a thermomechanical load consisting of thermal shocks and vibrations. The picture shows the relevant rollers and an exemplary process strategy to obtain grooves with sharp edges inside the joint tubes.

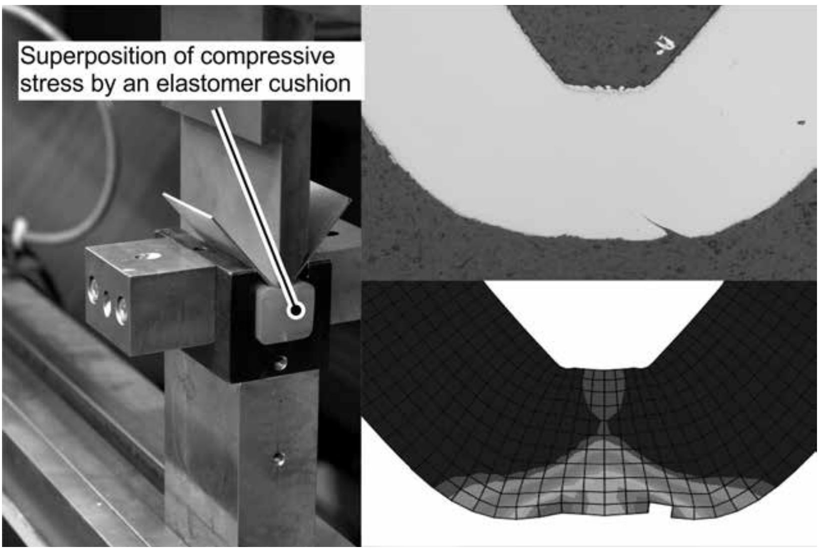


Rollers and an exemplary process strategy for the manufacturing of a form-fit joint

3.5.7 Forming Limit Extension of High-Strength Steels in Bending Processes by Using Innovative Process Management

Funding	AiF/FOSTA
Project	IGF-Nr. 16585/P 930
Contact	Dipl.-Ing. T. Clausmeyer
Status	Completed

Small bending radii are often requested for industrial bending parts. When using high-strength steels, such radii lead to an undesired early fracture. The tendency to springback-induced geometrical shape deviations increases with the strength of the material. The failure and springback behavior in air bending (see figure b) and c)) and roll forming was analyzed in this project. The process limits of air bending were extended significantly with the help of an elastomer cushion for advanced high-strength steel. Springback was reduced and the forming limits were extended. Suitable process parameters such as the position of the elastomer cushion (see figure a)) were determined by experimental analyses and process simulations with a Lemaitre damage model. A desired reduction of the force on the elastomer cushion was achieved. A demonstrator part was successfully manufactured by air bending and roll forming on the basis of these findings.

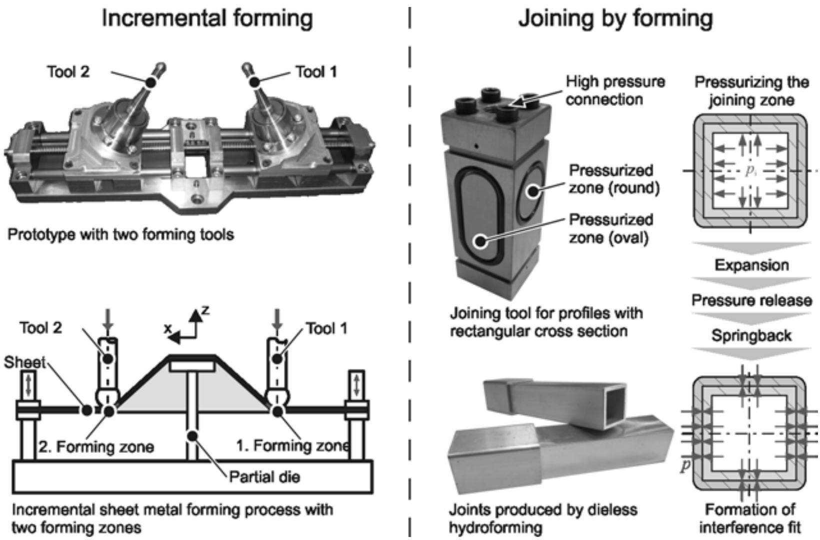


a) Air bending with elastomer cushion, b) micrograph after air bending, c) prediction of damage

3.6 Department of Non-Conventional Processes

Head Dr.-Ing. Dipl.-Wirt.-Ing. Christian Weddeling (until August 31, 2015)
Dipl.-Wirt.-Ing. Soeren Gies (since September 1, 2015)

Technological limits of conventional forming processes are the basic motivation for the activities in the Department of Non-Conventional Processes. Aiming at an extension of forming limits or a widening of the spectrum of processible materials, new forming techniques are developed or combined with established technologies. The field of research focuses on forming at high strain rates, incremental forming, and joining by forming technologies.
In the field of high speed forming processes a new project was started at the beginning of 2015 which deals with the additive manufacturing of coil turns for electromagnetic forming processes.
An increased efficiency is the main objective of two new projects in the field of incremental forming. Multiple forming zones as well as an increased speed of the forming tools are the main instruments within these projects.
Joining by die-less hydroforming is the topic of a project which started in the summer of 2015. By focusing on profiles with non-rotationally-symmetric cross sections, the field of application for this technology should be extended.

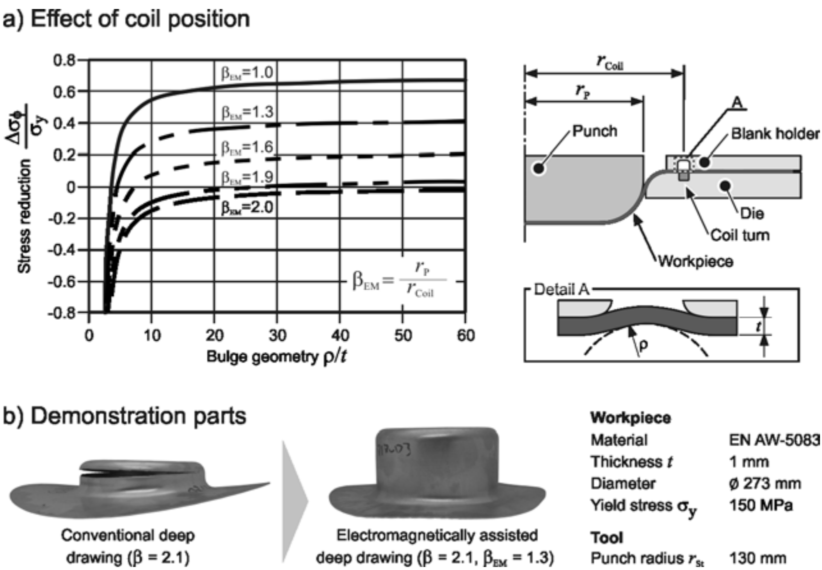


Left: Incremental sheet metal forming with multiple forming zones, Right: Joining by die-less hydroforming of profiles with non-rotationally-symmetric cross sections

3.6.1 Deep Drawing with Integrated Electromagnetic Forming

Funding	German Research Foundation (DFG)
Project	TE 508/10-2 • PAK 343 • Subproject 1
Contact	Dr.-Ing. Dipl.-Wirt.-Ing. C. Weddeling
Status	Completed

Subproject 1 within the joint project PAK343 was successfully completed in September 2015. The main objective was the extension of the process limits of the deep drawing process by superposing a sequential electromagnetic forming operation.
Based on experimental and numerical analyses, a working window was determined for this combination of quasi-static and dynamic forming processes. An increase of the drawing ratio from 2.0 in case of a conventional deep drawing process to 2.1 for the electromagnetically assisted drawing operation was realized. As shown in the figure below (part b), the maximum drawing depth was increased by up to 73%. The positive effect of the electromagnetically formed bulge in the flange region can be attributed to a temporary decrease of the meridional stresses in the cup wall. This stress reduction is as a function of coil position and formed bulge geometry (see figure, part a), and was determined analytically. The knowledge about this correlation of coil position, bulge geometry, and stress reduction is a useful instrument for the tool and process design.



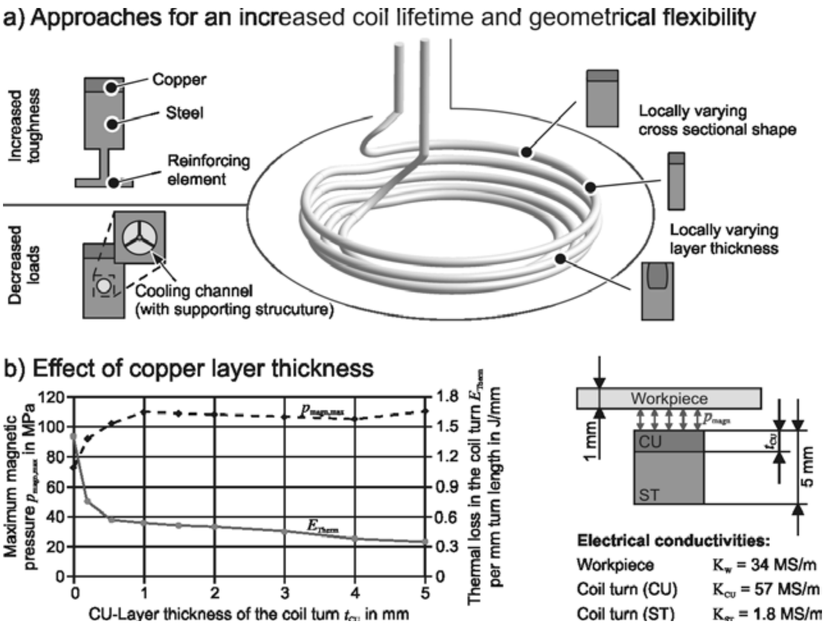
a) Effect of the coil position on the stress reduction and b) resulting cup geometries

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

Funding	German Research Foundation (DFG)
Project	TE 508/51-1
Contact	Dipl.-Wirt.-Ing. S. Gies

An extended working coil lifetime and an increased flexibility in terms of coil design are the main objectives of the joint project started in spring 2015 in collaboration with the Institute of Machine Tools and Factory Management (IWF) of the TU Berlin.

In the first step the Institute of Forming Technology and Lightweight Construction focuses on the analysis of the thermomechanical loads acting on working coils in electromagnetic forming processes. Based on these results, strategies for an increased toughness of the coil winding or a decreased load spectrum are derived. Potential methods are additional reinforcing elements, integrated cooling channels, or a hybrid design of the coil cross section (see figure a). In case of the hybrid design, a copper layer is used to reach a good electrical conductivity whereas the steel substrate ensures a high mechanical toughness. The effect of a varying copper layer thickness on the maximum magnetic pressure and the thermal losses is shown in figure b.

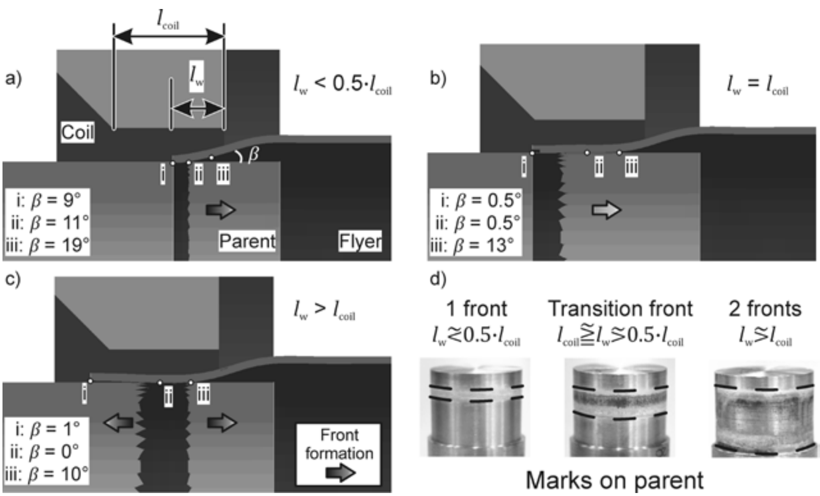


a) Approaches for an increased coil lifetime and geometrical flexibility, b) Effect of copper layer thickness

3.6.3 Magnetic Pulse Welding: Targeted Manipulation of Weld Seam Formation

Funding	German Research Foundation (DFG)
Project	SPP 1640 • Subproject A1
Contact	Dipl.-Wirt.-Ing. J. Lueg-Althoff

The focus of the current second funding period of the project, which is performed in cooperation with the Institute of Manufacturing Technology at TU Dresden, is on the investigation of the influence of joining zone parameters on the weld seam formation during Magnetic Pulse Welding (MPW) by electromagnetic compression. Based on the results of the first funding period, the influence of different surface treatments and coatings on the weld formation and the achievable joint strength is investigated. Another research topic within the project is the geometric design of the joining zone with respect to the welding front formation (see figure). The so-called working length, which defines the relative position of the flyer part in the working zone of the tool coil, is a crucial parameter for a successful welding process. For various combinations of joint geometries and discharge circuit characteristics specific optimum values of the working length were identified by experimental, numerical, and analytical methods. Exceeding those values leads to conditions which are unfavorable for welding.

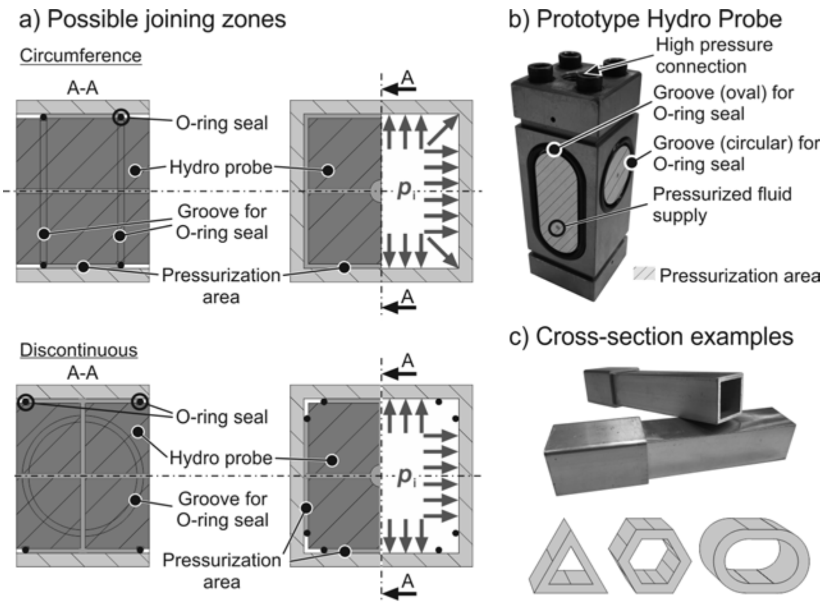


Welding front formation depending on working length: simulation of impact process (a-c), marks on parent parts (d)

3.6.4 Joining by Die-Less Hydroforming of Profiles with Non-Rotationally-Symmetric Cross Section

Funding German Research Foundation (DFG)
Project TE 508/50-1
Contact M.Sc. M. Müller

Joining by die-less hydroforming is already used in the production of camshafts and heat exchangers with circular cross-sections. The objective of the project is the extension of the process limits to enable form-fit and interference-fit joining of profiles with polygonal and oval cross sections, as shown in figure c). The focus of the project is on the development of analytical models for process and joint design and for predicting achievable joint strengths as a result of stress and strain distribution in the joining partners. For validation, joining experiments are used to identify the effects of various combinations of materials and process parameters. Currently, the research work concentrates on the further development of the prototype hydro probe, shown in figure b, to ensure a process-safe pressurization of the joining zone (see figure a: possible joining zones). The major challenge is to design a tolerance-compensating and low-wear sealing system.

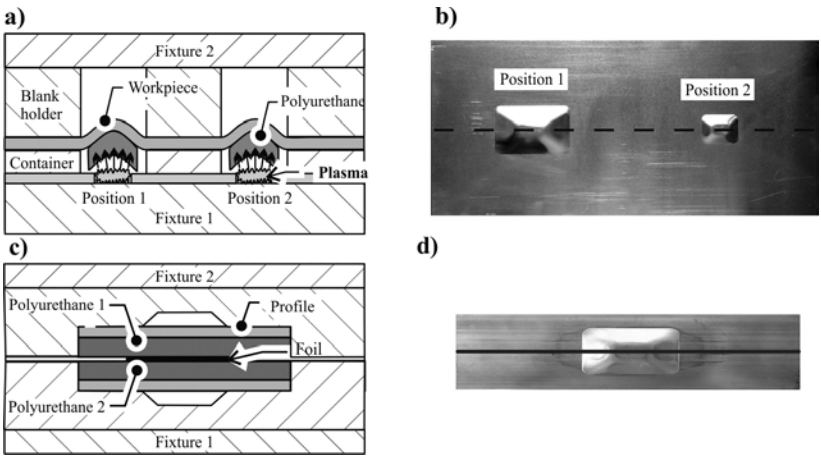


Tool concepts and examples of different cross-sections of the joining partners

3.6.5 Tailored and Mutual Pressure Distributions for Vaporizing-Foil Forming

Funding German Academic Exchange Service (DAAD)
Contact M.Sc. S. Cai
Status Completed

Metal forming by vaporizing foils is an innovative impulsive forming method. In this process metallic foils or wires are rapidly vaporized by high pulsed electrical currents. Hence, a fast expanding plasma which generates an intensive mechanical pressure pulse is formed. The aim of the project is to realize tailored pressure distribution to improve the forming accuracy and double-direction pressure distribution in order to enhance the energy efficiency and productivity in manufacturing.
An analytical model for the prediction of the acting pressure amplitude was developed. Additionally, a tailored pressure distribution and a double-direction pressure distribution were realized based on experimental investigations regarding general process parameters. A part with different forming depths was successfully manufactured by the tailored pressure distribution. The vaporizing foil technology was also used for forming of profiles. Using the double-direction approaches, a bulge was formed into two opposing sides of the profile in one forming step (see Figure).

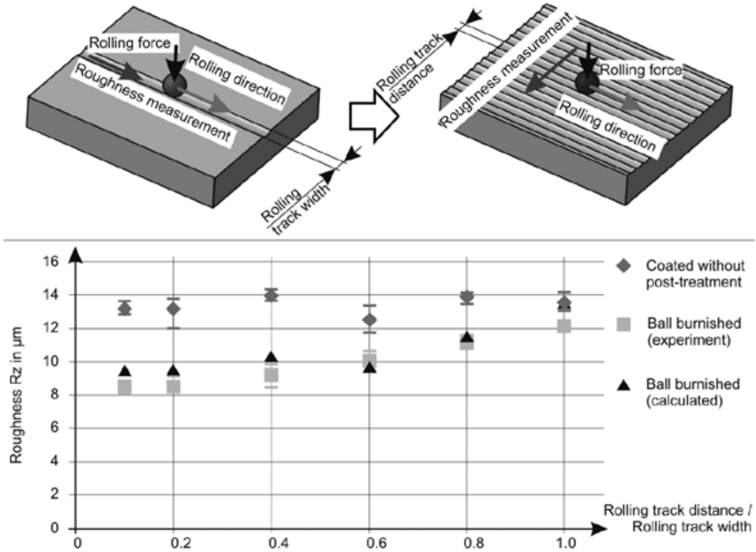


Metal forming by vaporizing foils: a) Tailored pressure distribution, b) Sheet metal forming, c) Double-direction pressure distribution, d) Profile forming

3.6.6 Optimization and Texturing of Coated Tool Surfaces by Local Plastic Deformation

Funding	German Research Foundation (DFG)
Project	SFB 708 • Subproject A3
Contact	M.Sc. L. Hiegemann
Status	Completed

The roughness of thermally coated surfaces can be decreased by an incremental forming process. This affects the tribological properties of the surface and makes it possible to use these post-treated coatings for wear protection of deep drawing tools. The surface topography after rolling depends on the materials to be processed as well as the rolling parameters. An analytical model developed within this project allows the prediction of the resulting roughness. This was initially limited to the determination of the roughness in the middle of one rolling track. Now, this model could be extended so that also the roughness of total areas can be predicted. Thereby, the rolling track distance is added as a further parameter. To be able to predict the roughness independently of the rolling tool used, the rolling track distance is related to the width of one single rolling track. A comparison between model and experimental data is shown in the figure. The calculated values are in good agreement with the experiments.

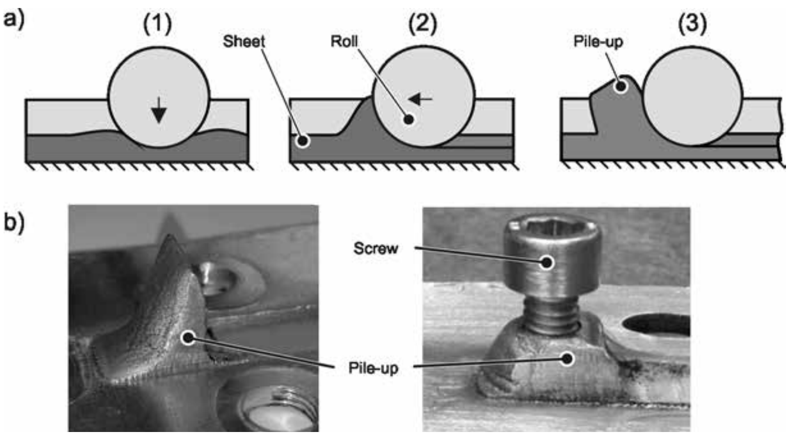


Experimental and analytical determination of the roughness after ball burnishing of thermally coated surfaces

3.6.7 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	Dipl.-Ing. P. Sieczkarek

The overall objective is the manufacturing of geometrically complex components with integrated functional and secondary design elements of thin sheets (2 – 3 mm) by forming operations. For this purpose, the incremental sheet-bulk metal forming process is used which is characterized by a material flow perpendicular to the sheet plane and a localized forming zone. This way, a local adaption of the workpiece contour and thickness is possible. Using a five-axis forming press, different incremental forming operations (rolling, upsetting, embossing) can be combined to a process sequence which offers even more flexibility.
Current research focuses on the local material concentration outside the sheet plane (Fig.). Using analytical and numerical approaches, the prevailing material flow is determined. This way, the influence of the process parameters on the resulting pile-up and the resultant forces can be analyzed. One possible application is a locally increased material volume for fasteners.

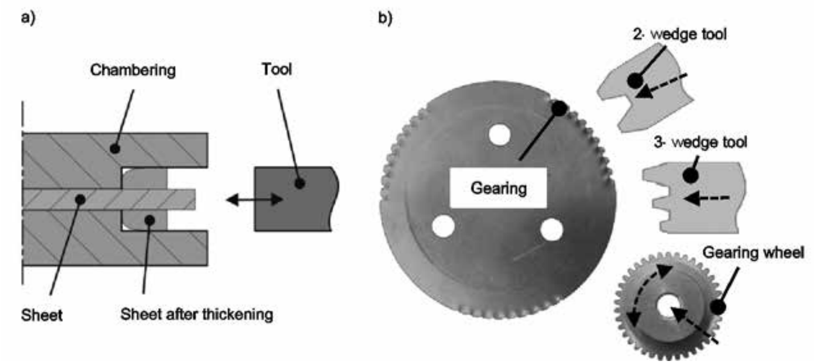


a) Rolling process in the sheet plane (schematically), b) Real material pile-up and application

3.6.8 Economic Manufacturing of Weight- and Load Adapted Functional Components by Incremental Sheet Bulk Metal Forming

Funding AiF
Project 18663 N/1
Contact M.Sc. S. Wernicke

Aim of the project is the economic manufacturing of industrially relevant functional components. The investigations focus on a defined thickening of the sheet edge (see figure a) followed by a gear forming operation (see figure b). To reach the aim of an economic manufacturing, the process will be accelerated close to real cycle times of industrial processes. The major challenge is to investigate and control the target conflict between the increased forming heat due to process acceleration and the desired strain hardening at the gearing. Further challenges are the process-typical tool loads combined with the unknown tribological system.
For the optimal process design material parameters which also consider the increased strain rate are necessary. These have been determined by tensile, pressure, in-plane torsion, and Nakajima tests. Current investigations deal with the economical process design in sheet bulk metal forming. Unlike in previous investigations, the new design includes rotating tools as well as a consideration of the influence of lubrication in the accelerated process.

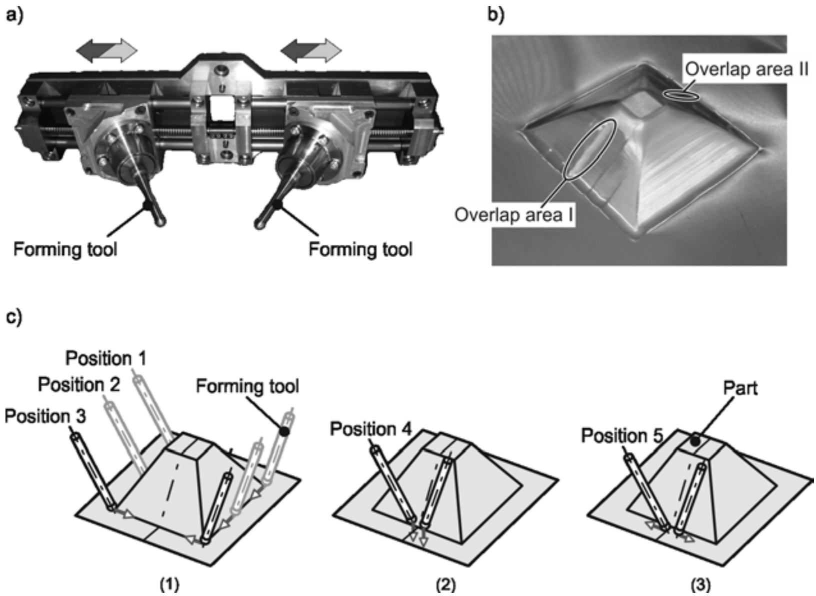


a) Thickening of the sheet, b) Gearing of the sheet by different tool layouts and kinematics

3.6.9 Incremental Sheet Forming by Multiple Simultaneous Forming Zones (MPIF)

Funding German Research Foundation (DFG)
Project TE 508/42-1
Contact Dipl.-Ing. T. Dang

Incremental sheet metal forming is characterized by flexible and low-cost manufacturing of hollow shapes. However, the process has long cycle times as a result of small forming tools to achieve higher dimensional and form accuracy. Therefore, it is only useful for the production of prototypes and parts in small batches. To decrease the production time per part, process strategies with multiple forming tools should be developed. This way, several zones on the sheet can be formed simultaneously. Based on this, many concepts with multiple forming tools were developed and patented. In addition, a prototype with two forming tools (Twintool, see figure a) was designed and tested. The preliminary test has shown that a reduction of the cycle time is possible by using specific interaction strategies of both tools. The interaction between the independent forming zones is to be investigated within the framework of this research project. For this purpose, the control technology of the Twintool has to be extended in order to develop appropriate forming strategies (figure c).

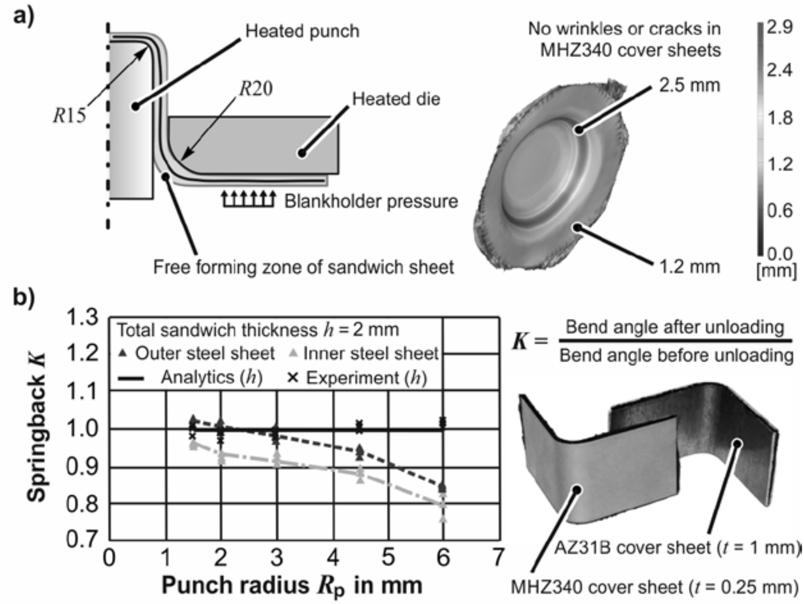


a) Prototype: Twintool, b) formed part, c) Forming strategy

3.6.10 Efficient Integral Manufacturing Processes to Form Metal-FRP Semi-Finished Sheet Products

Funding	BMBF/PTKA, Promotion Platform FOREL
Project	02PJ2772 (Collaborative project LEIKA)
Contact	M.Sc. M. Hahn

The applicability of mass-production-suitable forming processes for semi-finished sandwich products developed by project partners is investigated to improve the lightweight potential of electric vehicles. Such products consist of carbon fiber-reinforced plastics (FRP) covered with metal sheets (microalloyed steels, Mg-alloys). By adjusting the process parameters such as blank-holder pressure, temperature, and drawing depth parts can be deep-drawn without wrinkles or cracks. However, due to the tool pressure thickening occurs in the free forming zone where the punch is not in contact with the workpiece (figure a). In die bending there is tool contact on all sides at the bottom dead center. In figure b it can be seen that the springback of the cover sheets is compensated by the solidification of the thermoplastic core layer. This observation was made for different punch radii and almost independent of the fiber orientation. This could also be shown analytically by employing sandwich theory.



a) Sketch and thickness distribution in deep drawing, b) Springback in V-die bending

3.7 Department of Applied Mechanics in Forming Technologies

Head **Dipl.-Ing. Till Clausmeyer**

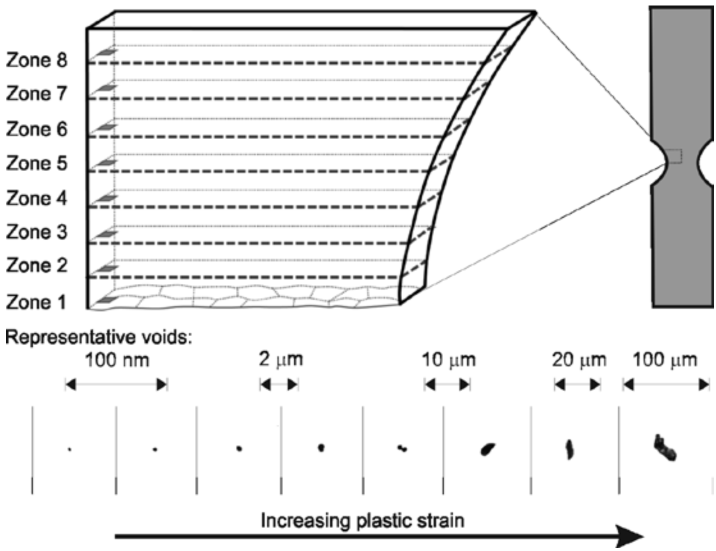
The analysis of forming processes with analytical and numerical models constitutes the main field of activity. The aim is to determine quantities which are difficult to measure and to obtain hints for possible improvements of processes. In this regard, new mechanical methods are implemented into finite-element-programs and applied in forming simulations. Simultaneously to model development for plasticity and damage, researchers improve methods for material characterization and parameter identification.
Currently, the blanking process of monolithic sheets and sandwich sheets as well as the damage in sheet forming are investigated. The influence of the evolution of microstructural defects on sheet-bulk forming processes is analyzed in the Collaborative Research Center SFB TR 73. Alexander-von-Humboldt scholar Dr. Yanshan Lou and Prof. Paulo Martins collaborated with the department in 2015. A new researcher joined the department in September to work in the field of adiabatic blanking.

Participants of the SFB TR 73 simulation workshop organized by the department

3.7.1 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 SFB/TR 73 • Subproject C4
Contact M.Sc. K. Isik

Sheet-bulk metal forming processes combine conventional forming of semi-finished sheets with bulk forming, i.e. a distribution of material across the thickness. The objective of this project is the experimental and numerical investigation of the microstructure and the corresponding damage behavior for this novel type of metal forming process. The void volume is measured in the highly deformed regions of the semi-finished and final product by scanning electron microscopy in collaboration with the Institute of Materials Science of Leibniz Universität Hannover. The figure shows representative void geometries in regions with increasing deformation. The simulation model correctly predicts the critical regions for the accumulated damage as observed in the micromechanical investigations. Alternatively, the damage is characterized indirectly. The change of elastic behavior of the material due to the evolved damage is detected. The natural frequency of the pre-strained specimens is measured to determine the anisotropy of the damage evolution.

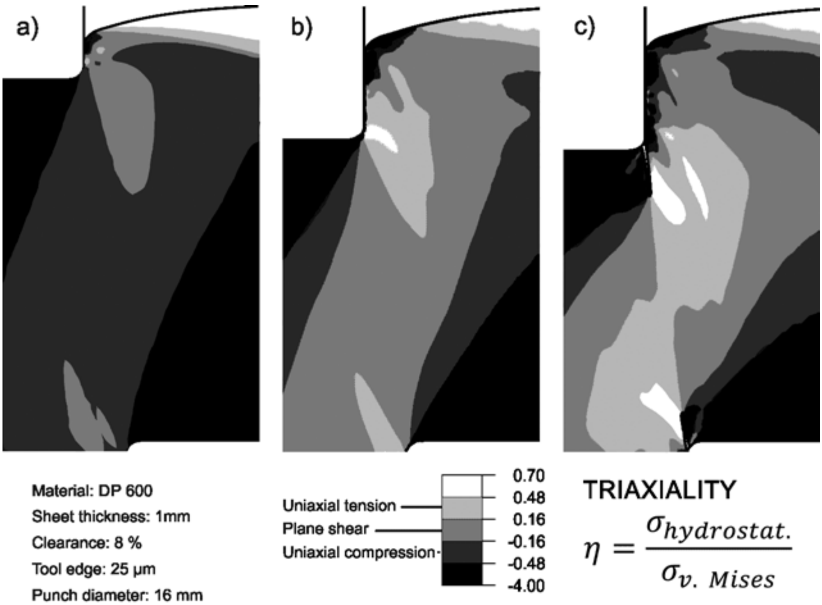


Evolution of the void volume in different zones of a tensile specimen with a notch

3.7.2 Software Tool for Robust Design of the Blanking Process of Metal Laminated Composite Material without Lubricants

Funding German Research Foundation (DFG)
Project TE 805/37-1
Contact M.Sc. F. Gutknecht

A software tool for the prediction of wear is developed together with the utg at TU München. At the IUL the blanking process of different types of sheets is analysed numerically with a Lemaitre damage model. Starting with monolithic sheets, more complex composites are considered to gain fundamental knowledge of the process. An automated strategy for parameter identification enables an efficient application of the damage model. Numerical investigations applying this model demonstrate the pronounced non-linearity of the blanking process and reveal a ratio of different stress states in the entire process. This is exemplified by the graphic below.
The project is embedded into the DFG/AiF coordinated research program “Dry Shear Cutting of Metal Laminated Composite Material”. Additional sub-projects are conducted at utg, PtU (Darmstadt), and IUL.

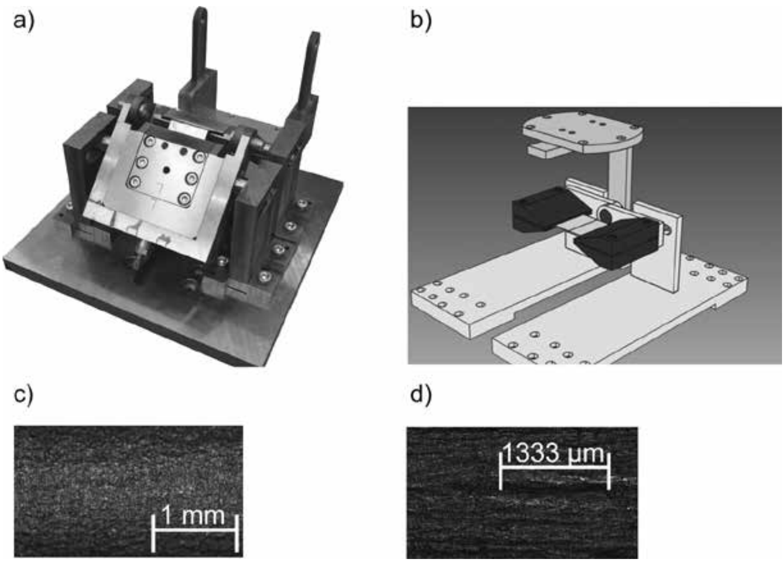


Stress state in blanking for punch displacements (relative to sheet thickness): a) 15 %, b) 26 %, and c) 28 %

3.7.3 Robust Material Modeling for Sheet Metal Bending

Funding ReCIMP
Contact Dipl.-Ing. T. Clausmeyer

The description of the material behavior of advanced high-strength steels during bending operations and under service load is necessary for the comparison of different material grades. Important aspects in the manufacturing process as well as during service are the failure behavior and the behavior during load reversals. A new experimental device for bending and unbending of sheets (see figure a)-b)) is developed based on the previous project in collaboration with Bilstein GmbH. The objective is to determine the influence of kinematic hardening and damage during unbending. A further objective is the description of the material behavior with proper material models which are suited for finite element simulations. The simulations are used to predict the properties of bent parts. The plane torsion test and tensile tests are used for the identification of material parameters. Failure is analyzed with the help of a light microscope. A new methodology for the assessment of failure in bending operations is applied.

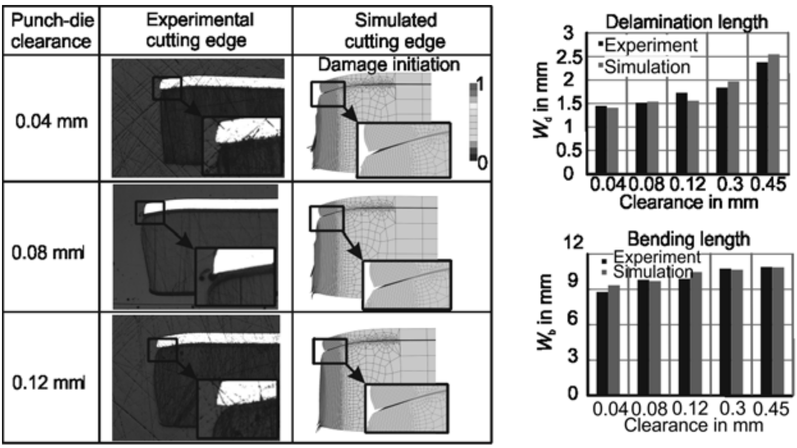


a) Manufactured bending device, b) CAD drawing, c) bent specimen without crack and d) with crack

3.7.4 Failure Mechanisms in Forming of Monolithic and Composite Plates

Funding German Academic Exchange Service (DAAD)
Contact M.Sc. L. Chen
Status Completed

Composite sheets are used for different applications, e.g. in civil engineering or for noise reduction. The focus is on investigations of failure mechanisms in forming of monolithic metallic and metal/polymer/metal sandwich plates. The mechanical behavior of the monolithic metallic sheets and each component of the half sandwich structure have been successfully characterized. At this stage, the separately characterized components are then combined in a blanking process simulation for the half sandwich structure. The effect of punch-die clearance on the cutting edge is studied quantitatively. Three defects, namely the bending angle, bending width, and the delamination, are defined to describe the deviation of the real cutting edge compared with the ideal cutting edge (see figure). The results from both experiment and simulation show that the smallest clearance generates the best quality of the cutting edge (see figure). The stress state of the metallic layer during blanking is analyzed taking advantage of the validated finite element model.

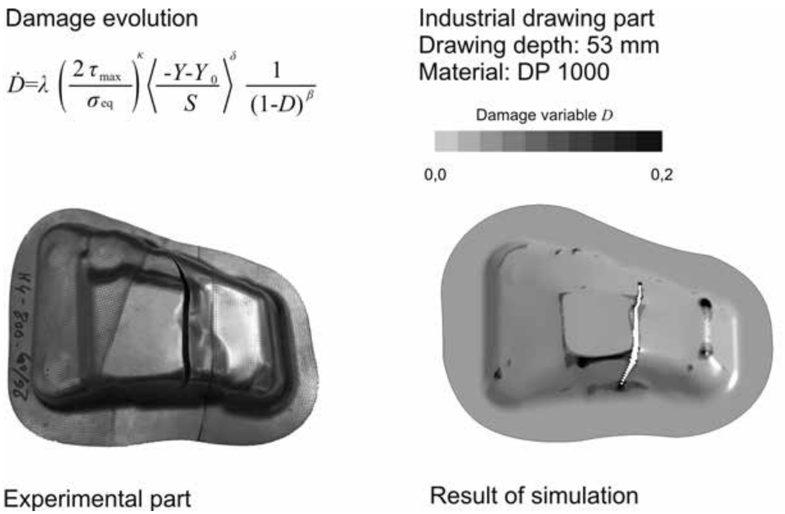


Experimental and simulation results of blanking of half sandwich structure

3.7.5 Enhanced Continuum Damage Mechanics Model for Low Triaxialities for the Deep Drawing Simulation of Advanced High-Strength Steels

Funding	FOSTA
Project	P 1039
Contact	Dipl.-Ing. T. Clausmeyer • M.Sc. K. Isik

A damage model which considers the effect of different stress states was developed to predict the failure of advanced high-strength steels in deep drawing. An important quantity for the onset of failure is the triaxiality, i.e. the quotient of hydrostatic and equivalent stress. Different characterization experiments (tension tests with different geometries, shear tests) were conducted to determine the plasticity and the damage behavior. In this regard, the analysis of several experimental setups with respect to the failure behavior due to shear loading or for low triaxialities is important. These experiments are used to identify material parameters for the material model in collaboration with the company inpro. The model is implemented into commercial software. The predictions of the simulation model are validated with the help of industrial drawing experiments (see figure). The objective is to obtain a more accurate prediction of failure. The project is supported by car manufacturers, software companies, and steel manufacturers.



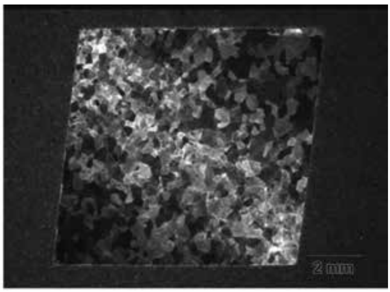
Comparison of finite-element simulation with modified damage model and experiment

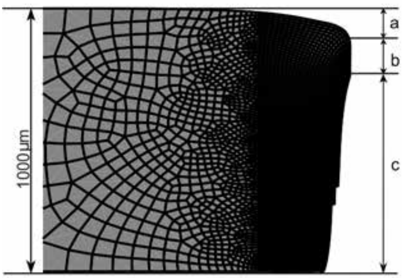
3.7.6 Simulation Strategies for the Application of Adiabatic Cutting in Sheet Metal Part Manufacturing in the Context of Material Science

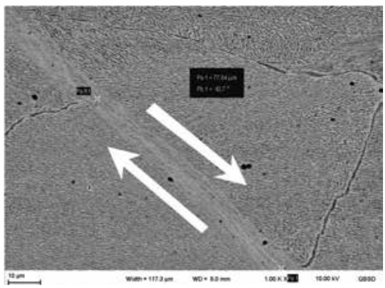
Funding AiF/FOSTA
Project 18865 BG – P 1127
Contact M.Sc. F. Schmitz

This project is a cooperation with the Institute of Materials Science and Engineering (LWT) of TU Chemnitz. Due to the high quality of the cutting surface adiabatic shear cutting is particularly suited for the processing of materials with extremely high strength. The high (local) strain rates ($\dot{\varepsilon} > 10^3\ s^{-1}$) lead to local temperatures of $T > 10^3$ °C. These high temperatures are accompanied by a local softening. However, a fundamental understanding of the process is still lacking in order to be able to establish an industrial application of adiabatic cutting of sheets. The objectives are to develop an experimentally validated simulation tool (exemplary simulation results are shown in the figure) which considers the relevant forming and microstructural processes. In this context, an improved understanding of the mechanical and microstructural analysis of the adiabatic cutting process is required. Especially the resulting shear bands (see figure) are in the focus of this project.

	a / t	b / t	c / t
Simulation	0,111	0,138	0,75
Experiment	0,067	0,22	0,72
Deviation in %	22,4	13,6	6,9







Left: Simulation result cutting process (material DP1000), right: Shear band formation in a Ti-10V-2Fe-3Al alloy (testing stopped at 10 % strain applied)/Images on the right by S. Winter (TU Chemnitz)

3.8 Patents

3.8.1 Published Patents

Title	Process for the Manufacturing of Tool Coils and/or Tools for the Electromagnetic Forming of Thin Walled Electrically Conductive Workpieces as well as Tool Coil Based on this Strategy

Application Number	DE 10 2013 013 335.1
Patentholder	TU Dortmund
Status	Published February 12, 2015
Inventors	A. Jäger • R. Hölker • J. Lueg-Althoff • L. Kwiatkowski O. K. Demir • A. E. Tekkaya

Title	Process and Device for Controlling the Forming Behaviour, Particulary the Springback when Forming Workpieces in Clocked Forming and Processing Stations, Particularly when Bending Progression Tools

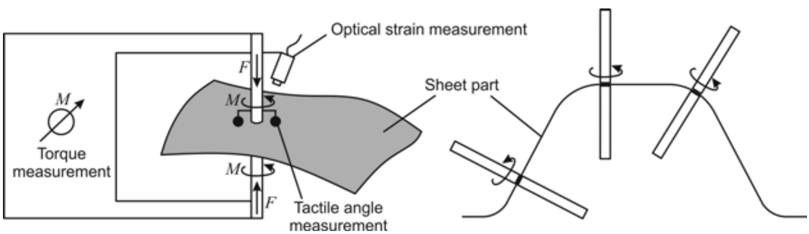
Application Number	DE 10 2014 001 872 A1
Patentholder	KODA Stanz- und Biegetechnik GmbH
Status	Published August 13, 2015
Inventors	C. Becker • M. Hermes • C. Löbbe • D. Putschkat A. E. Tekkaya

3.8.2 Filed Patents

Test Methods and Test Equipment for a Non-Destructive Determination of Strength and/or Forming Technique –Relevant Material Properties of Sheet Metal Components to be Tested Based on the In-Plane Torsion Test

Application number	DE 10 2015 005 146
Patent applicant	TU Dortmund University
Status	Filed
Inventors	A. E. Tekkaya • Q. Yin

The testing of components for determining the local strength is very costly depending on the complexity. In most cases the part will be destroyed for the testing process so that the additional use is no longer given. A new process was invented by applying the in-plane torsion test locally on a part, using a miniaturized and curved stamp. Thus, a non-destructive and mobile strength test was invented which enables for the first time testing even under production conditions.The basis of the invented method is the local torsion of a component (see figure) to the beginning of the plastic deformation, in order to determine the beginning of plastic yielding. A measurement of surface deformation will be done in the test either by tactile or by an optical measurement system. The small size of the stamps used and the very small deformations make this process quasi non-destructive and by an analytical calculation of the stress from the measured torque the yield stress at the measuring point is determined. This can be done independent of the geometry of the component and the shape of the surface.



Principle of mobile and non-destructive strength testing with in-plane torsion

Procedure and Equipment for the Determination of Material Coefficients, Especially of Flow Curves for Lightweight Materials, Especially for Extrusion

Application number	DE 10 2015 007 867
Patent applicant	TU Dortmund University • ISPT GmbH & Co. KG
Status	Filed
Inventors	T. Kloppenborg • A. E. Tekkaya

The simulation of extrusion processes by using lightweight materials such as aluminum and magnesium is increasingly used in the industry for a detailed analysis and optimization of extrusion processes and dies. With the help of the new procedure and equipment a characterization of aluminum for simulation becomes feasible with a high efficiency regarding time and costs. With this approach a realistic characterization of materials under high hydrostatic pressure, high strains, and high temperature is feasible.
For the characterization, cylindrical samples are pressed through a die similar to a conventional extrusion process. The forming of the material is homogenous in the cross-section of the container during the process for positions in a sufficient axial distance from the die orifice. Here, the material is sheared under high pressure and temperature close to the container wall. The innovation of the characterization equipment is to measure the shear forces at the surface area of the container. This can be done in one or in multiple sections along the container. Based on these measuring results, a calculation of material coefficients can be obtained.

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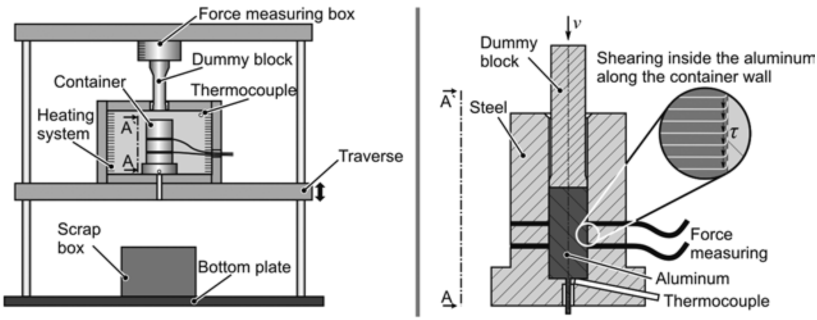
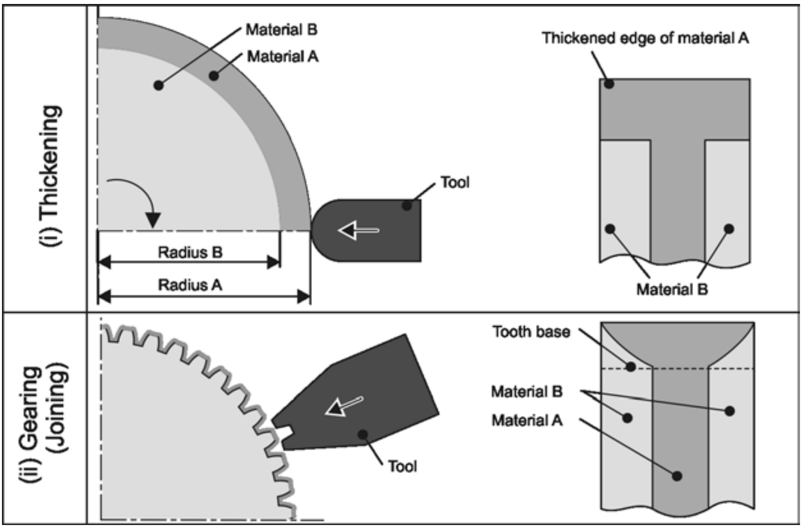


Equipment for the characterization of lightweight material

Process for the Manufacturing of a Multi-Layer Sheet Metal Body

Application number	DE 10 2015 015 388.9
Patent applicant	TU Dortmund University
Status	Filed
Inventors	S. Wernicke • P. Sieczkarek • S. Gies N. Ben Khalifa • A. E. Tekkaya

Load-adapted functional components made of thin sheets can be manufactured using the technology of incremental sheet-bulk metal forming. Due to prevailing tool loads the application of high-strength materials is currently limited. The invention offers the possibility of processing several stacked sheet workpieces with different material properties. Here, the individual sheet layers have different dimensions. By reducing the diameter during a simultaneous rotation of the workpiece the outer high-strength material (A) is thickened (i). Subsequently, the gear elements are formed incrementally (ii). Thus, a positive form and force connection can be achieved in the sheet composite. Since the forming of the gearings occurs mostly in the softer material (B), the tool load decreases. This enables the production of sheet components with a high-strength gearing in the outer active region. Moreover, the combination of different materials increases the lightweight and application potential of the load-customized components.



Principle of the manufacturing process of a multi-layer sheet metal body

Further Activities

04

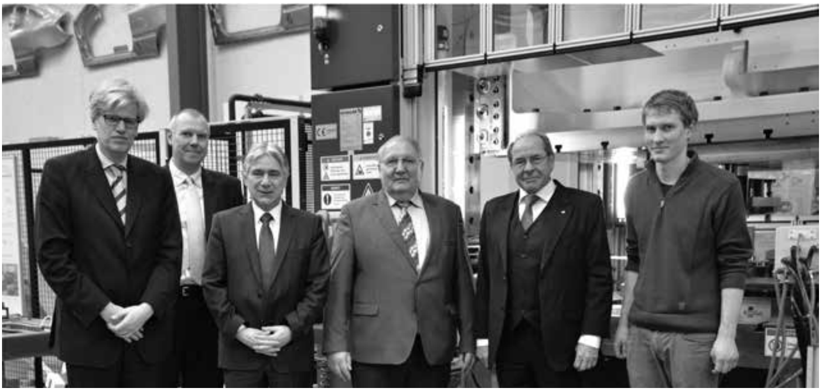
4 Further Activities

4.1 Conferences and Meetings

In 2015 diverse conferences and workshops were hosted or co-organized by the Institute of Forming Technology and Lightweight Construction to present research results and to meet researchers from industry and universities. In the following, you will find more information on selected events.

Meeting with Prof. Dr. Wucherer and representatives of "KODA Stanz- und Biegetechnik GmbH"

Prof. Dr. Klaus Wucherer, IEC Vice President and member of the National Academy of Science and Engineering (acatech), visited the Institute of Forming Technology and Lightweight Construction on February 6, 2015, with representatives of the company "KODA Stanz- und Biegetechnik GmbH" to promote the exchange between industry and academia. The meeting topics covered sustainability aspects of forming technology, current developments for application-oriented research with industry participation, and the education strategy to promote highly committed and motivated students by international courses.



Benedikt Kummer, Detlef Putschkat, Prof. A. Erman Tekkaya, Prof. Winfried Pinninghoff, Prof. Klaus Wucherer, Christian Löbbe

During the institute tour current areas of research, e.g. the telemetric experimental setups for material characterization, were presented. Furthermore, the tour focused on new bending technologies as profile bending with torque-superposed stresses and other profile forming processes. Special attention was given to the innovative process of warm forming in progressive dies which has been developed in cooperation between the company KODA and the IUL. The main principle was demonstrated on the basis of a prototype die driven by a servo press.

18th Workshop on "Simulation in Forming Technology" & 3rd Industrial Colloquium of the CRC/TR 73 (SFB/TR 73)

On February 26 and 27, the workshop on "Simulation in Forming Technology" took place as a combined event with the "Industrial Colloquium of the Transregional Collaborative Research Center on sheet-bulk metal forming (SFB/TR 73)". The guiding topic was "tribology". The simulation workshop was divided into a bulk forming (1st day) and a sheet metal forming session (2nd day). In between, a fluent transition was created with the innovative technology of sheet-bulk metal forming investigated in the SFB/TR 73. Representatives of industry have presented the industrial view on the latest developments and challenges of metal forming simulations. Furthermore, the possibilities and advantages offered by the new technology of sheet-bulk metal forming were also presented. International speakers as well as representatives of the SFB/TR 73 and of the SPP 1676 (Dry Metal Forming) discussed these topics from a scientific point of view. The breaks between the presentations provided an opportunity for discussions. These were intensified during lunch, which took place in the experimental area of the IUL. A guided tour focusing on the technical equipment was also offered. The Maschinenbau III building of TU Dortmund University with its inviting design served as venue and contributed to the big success of the entire event.

Welcome by Prof. Tekkaya and Prof. Liewald, participants of the event

10th Meeting of the IUL Industrial Advisory Council

Established in 2010, the Industrial Advisory Council meets twice a year with the aim of supporting the IUL in its strategic alignment of application-oriented research. In addition to the transfer of research results into industrial environments, the Advisory Council is characterized by advising the institute on the implementation of collaborative research projects. Therefore, the council gives valuable input regarding industrial technologies and research needs and, in return, receives detailed results of basic research and innovation. The first meeting of the year took place on April 17, 2015. The topics of its discussions focused especially on the extrusion process simulation, hybrid structures and press hardening. At the tenth meeting of the panel in its fifth year, the Industrial Advisory Council celebrated its anniversary on November 30, 2015. The presentation of a retrospective of the years 2010-2015 was the basis of the anniversary meeting and contained, among other things, completed disserations, the foundation of the research center for industrial metal processing (ReCIMP) as well as the extpansion of the institute's machinery. The subsequent constructive discussion took up the Industry 4.0 topic and the transfer of innovation into practice. Both meetings were enriched by valuable presentations held by members of the Industry Advisory Council.

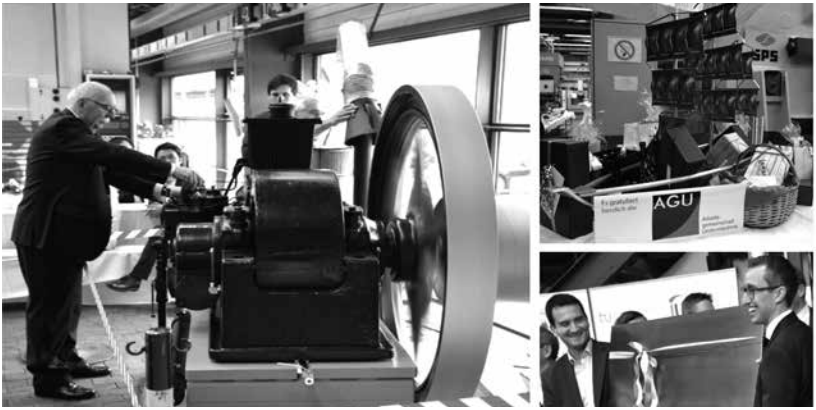
Anniversary meeting of the IUL Industrial Advisory Council

Colloquium on the Occasion of Professor Kleiner's 60th Birthday

On June 19, 2015, a colloquium on the occasion of Professor Matthias Kleiner's 60th birthday was organized at the Institute of Forming Technology and Lightweight Construction. Around 130 guests accepted the invitation to come to Dortmund. After an official reception of the guests and an opening speech by Professor Tekkaya, Professor Kleiner was honored by friends and companions: Professor Matthias Liewald (University of Stuttgart), Dr. Hans-Joachim Wieland (FOSTA), Professor Alexander Brosius (TU Dresden), Professor Hartmut Hoffmann (TUM), Professor Werner Homberg (Paderborn University), and Dr. Ferdinand Hollmann (DFG). Professor Ursula Gather, TU Dortmund University's Rector, acknowledged his extraordinary career and thanked Professor Matthias for his achievements for the University.

Rector Prof. Ursula Gather und Prof. A. Erman Tekkaya congratulate Prof. Matthias Kleiner, handing over their gifts; Publication „60 Excellent Inventions in Metal Forming“

Following the speeches, Professor Tekkaya presented a book entitled "60 Excellent Inventions in Metal Forming" as a gift for Professor Kleiner. It is a joint project of friends from the international forming community honoring Professor Kleiner's scientific and technological contributions. The event continued in the experimental hall where Professor Kleiner received further gifts as a stylized sailing vessel manufactured by forming by members of the "Arbeitsgemeinschaft Umformtechnik (AGU)". Its hull is made of curved aluminum profiles. The sail is composed of several cup-shaped sheet metal segments bearing the names of the AGU member institutions. The Institute of Forming Technology and Lightweight Construction handed over a "photo metal sheet" produced by laser technology, showing the experimental hall of the IUL and the famous "Dortmunder U". It is symbolic for Professor Kleiner's



On the left: Demonstration of the single-cylinder engine, On the right, top: Stylized sailing vessel manufactured by forming, On the right, bottom: „Photo metal sheet" showing the experimental hall and the "Dortmunder U"

commitment and love for his hometown Dortmund.
A highlight of the evening was the demonstration of an old Christoph single-cylinder engine with 14 liters capacity built in 1920. Professor Kleiner saved it from being scrapped and took care of its restoration.
Concluding, the guests enjoyed the evening in the experimental hall. The event was organized by Professor Werner Homberg, Professor Alexander Brosius, and Professor A. Erman Tekkaya. Sincere thanks to the many helpers who made sure that the event was a great success and to everyone who has been involved in manufacturing the gifts and creating the book.

IUL Excursion

A close contact to partner institutes and industry is the basis for innovations at IUL. Only in this way the needs and developments in metal forming can be fully recognized and taken into account. For this reason, the Institute of Forming Technology and Lightweight Construction organized a three-day excursion with 46 employees in September 2015 to share experiences and knowledge in the northern part of Germany. The first station of the trip was Bremen. In small groups the team spirit was strengthened by sharing various social activities. The day was rounded off with a dinner at the Bremer Ratskeller restaurant. The next day, the Daimler AG was visited to see the pressing plant and tooling and current challenges in this field were been discussed. In the afternoon, the partner institute of Prof. Behrens (IFUM, Leibniz Universität Hannover) was visited. The get-together of the participating cientists led to an active exchange about current research topics. On the last day the company Winkelmann Powertrain Components GmbH + Co. KG gave us an imposing insight into their economic use of the sheet-bulk metal forming.

Group photo of the IUL employees in Bremen

PAK 343 & I²FG Workshop on Electromagnetic Pulse Forming and Joining 2015

On October 5 and 6 this year, the combined event "PAK 343 & I²FG Workshop on Electromagnetic Pulse Forming and Joining" took place in Dortmund. The Institute of Forming Technology and Lightweight Construction (IUL), the host of the event, is member and at the same time the administrative office of the "International Impulse Forming Group" (I²FG), which acts as a promoting platform for science in the field of impulse forming. The 6th general assembly of the I²FG was also part of the workshop. Furthermore, the event provided an international forum for the presentation of results of the project "Development of a methodology regarding combined quasi-static and dynamic forming processes"(PAK 343), funded by the German Research Foundation (DFG). For two days more than 30 attendees from science and industry coming from America and Europe actively participated in innovative talks about the whole spectrum of impulse forming, ranging from the combination with conventional processes to magnetic pulse welding. Here, the core aspects were "technology", "simulation" as well as "material behavior". Professor Tekkaya, Professor Reese, Professor Stiemer, Professor Maier, and Dr. Faes would like to thank the speakers und attendees for a successful event.

Group photo with all participants

PAK 343 overview given by Prof. Tekkaya

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

- Stahl fliegt (Flying steel) • June 16 – 17
- SchnupperUni • August 6
- do-camp-ing • June 28 – July 3
- Open Day of TU Dortmund • October 24

4.2 Awards

„Best Paper Prize" ICEB 2015

During the „International Conference on Extrusion and Benchmark" (ICEB 2015), which this year took place together with the conference „Aluminium 2000" from May 12 to 16 in Florence/Italy, Dr. Ramona Hölker-Jäger was awarded the "Best Paper Prize" in the category "Extrusion" for her publication entitled "Hot extrusion dies with conformal cooling channels produced by additive manufacturing". In her paper and presentation Dr. Hölker-Jäger showed the results of additively manufactured hot extrusion dies with local inner cooling. By using these novel dies, a significant increase in productivity can be realized during hot extrusion of light metals.

Award ceremony during the gala dinner: Prof. Lorenzo Donati (University of Bologna) congratulates Dr. Ramona Hölker-Jäger (IUL)

IUL receives Steel Innovation Prize 2015 for Incremental Profile Forming Process

On June 9th, 2015 the "Incremental Profile Forming Process", developed at the Institute of Forming Technologies and Lightweight Construction (IUL), was awarded the third place of the Steel Innovation Prize in the category "Steel in Research and Development" by Prof. Johanna Wanka, Federal Minister of Education and Research. Prof. A. Erman Tekkaya, Dr. Christoph Becker, Goran Grzancic and Prof. Matthias Hermes (University of Applied Sciences Südwestfalen) developed an innovative manufacturing technology for the flexible

manufacturing of profiles made of high-strength steels with a high geometric complexity. It combines strategies of material and component lightweight design.
The Steel Innovation Prize was awarded for the tenth time this year. The prize is one of the most prestigious contests and it did not lose any of its attraction in the last 26 years. 578 projects were submitted in 2015. There is no comparable contest in Germany with this many participants.

Federal Minister Prof. Johanna Wanka, Dr. Christoph Becker und Ranga Yogeshwar (from left to right), Photo: German Steel Federation

Awarded with the Steel Innovation Prize 2015: Dr. Christoph Becker, Prof. Matthias Hermes (University of Applied Sciences Südwestfalen), Prof. A. Erman Tekkaya, and Goran Grzancic (from left to right) Picture: Roland Baege/TU Dortmund University

Third Prize in Zwick Science Award 2014

Every year, the material testing machine producer Zwick Roell awards the international Zwick Science Award in order to honor the innovative application of material testing devices in scientific research. This year, Dr. Alper Güner won the third prize for his publication with the title "In-situ measurement of loading stresses with X-ray diffraction for yield locus determination". The award ceremony took place during the "6th Zwick Academia Day" on June 2, 2015 at ETH Zürich. Besides well-known Professors also the prize winners had the opportunity to present their works to an international audience.

Winners and the jury members of the Zwick Science Award 2014 (Dr. Güner at center)

IUL team wins student competition „Stahl fliegt 2015"

The competition "Stahl fliegt", sponsored by Forschungsvereinigung Stahlanwendung e.V. (FOSTA), took place on June 16 and 17 in Aachen and Düsseldorf. More than 80 students from seven German universities participated in this competition, which was organized by the Institute of Metal Forming (IBF) at RWTH Aachen University. The first day, the teams presented their aircrafts in brief presentations in the Super C Building at RTWH Aachen. The total weight of the aircrafts was limited to 400 Grams. On day two, the competition continued in the fair hall 6 of Messe Düsseldorf fairground, hosting the fairs Metec, Gifa, Thermprocess, and Newcast at the same time. Each team dropped its aircrafts by hand from a height of approximately 10 meters, being allowed 5 attempts to reach the longest flight time before touching the ground. With a maximum flight time of 17 seconds, the IUL team (see photo) won the first place, followed by the teams from the Universities of Bremen and Kassel. The winners, numerous participants of the competition, and representatives of the responsible institutions IBF and FOSTA participated in the award ceremony.

Successful IUL team. Photo: FOSTA, Düsseldorf

4.3 Participation in National and International Organizations: Prof. Dr.-Ing. Dr.-Ing. E.h. A. Erman Tekkaya

Memberships of Research Boards

- acatech – Member of the “German Academy of Science and Engineering” (“Deutsche Akademie der Technikwissenschaften”), acatech ambassador at TU Dortmund University
- AGU – Member of “Wissenschaftliche Arbeitsgemeinschaft Umformtechnik“
- CIRP – Fellow of the “The International Academy for Production Engineering”
- Curatorship member of “KARL-KOLLE-Stiftung“, Dortmund, Germany
- DGM – Member of ”Deutsche Gesellschaft für Materialkunde“
- ESAFORM – Member of the Scientific Committee of the “European Association for Material Forming”
- GCFG – Member of the ”German Cold Forging Group”
- Honorary member of the “TechNet Alliance”
- ICFG – Member of the ”International Cold Forging Group“
- ICTP – Member of the Standing Advisory Board of the “International Conference on Technology of Plasticity”
- I^2FG – Member of the „International Impulse Forming Group”
- JSTP – Member of “The Japan Society for Technology of Plasticity”
- Member of the Scientific Advisory Board of “Exzellenzcluster Integrative Produktionstechnik für Hochlohnländer”, RWTH Aachen University, Germany
- Member of “DGM Regionalforum Rhein-Ruhr“
- Member of the “German Academic Society for Production Engineering” (WGP: „Wissenschaftliche Gesellschaft für Produktionstechnik“)
- Member of the advisory board, “Max-Planck-Institut für Eisenforschung GmbH”
- Vice president of the consortium of “Türkisch-Deutsche Universität” (Turkish-German University)

Journals/Editorship

- Editor-in-Chief, "Journal of Materials Processing Technology" (Elsevier)
- Member of the CIRP Editorial Committee 2016, Paris, France
- 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 International Advisory Committee, "International Journal of Material Forming" (Springer)
- Member of the International Advisory Committee, "Romanian Journal of Technical Sciences – Applied Mechanics"
- Member of the International Editorial Board, Journal "Computer Methods in Materials Science"
- Member of the Scientific Editorial Board, "International Journal of Precision Engineering and Manufacturing" (Springer)
- Vice Chairman of the Editorial Committee "CIRP Annals"

Further Memberships

- DAAD Scholar Committee, Ankara, Turkey
- IUTAM – "Turkish Branch of the International Union of Theoretical and Applied Mechanics", Turkey
- Member of the CIRP Communication Committee
- Member of the Scientific Committee, "The 26th CIRP Design Conference 2016", Stockholm, Sweden
- Member of the Scientific Committee, "The 23rd CIRP Conference on Life Cycle Engineering" (LCE2016), Berlin, Germany
- Member of the Scientific Committee, "International Conference on high speed forming" (ICHSF 2016), Dortmund, Germany
- Member of the Scientific Committee, "4th International Conference on steels in cars and trucks" (SCT 2017), Amsterdam, The Netherlands
- Member of the Scientific Committee, "The 16th International Conference Metal Forming" (Metal Forming 2016), Krakow, Poland
- Member of the Scientific Committee, "The 16th International Conference on Sheet Metal" (SheMet 2015), Erlangen, Germany
- Turkish-German Cultural Association, Ankara, Turkey
- Member of the Scientific Committee „The 12th International Conference

on Numerical Methods in Industrial Forming Processes" (Numiform 2016), Troyes, France
- Member of the Scientific Committee "International Deep Drawing Research Group 2015" (iddrg), Shanghai, P. R. China

Activities as Reviewer

In Scientific Committees

- AiF – Arbeitsgemeinschaft industrieller Forschungsvereinigungen „Otto von Guericke" e. V. (AiF)
- Academic Council of the King Saud University
- CIRP – International Academy for Production Engineering
- DFG – German Research Foundation, Member of Fachkollegium 401 (Review Board on Production Engineering)
- External Advisory Committee, Department of Mechanical Engineering, KAIST, Republic of Korea
- North Carolina State University
- Steel Institute VDEh

For Journals

- Applied Mathematical Modelling
- ASME – Journal of Manufacturing Science and Engineering
- CIRP Annals-Manufacturing Technology
- CIRP Journal of Manufacturing Science and Technology
- Computational Materials Science
- Computer Methods in Applied Mechanics and Engineering
- Engineering with Computers
- 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 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 of Applied Mathematical Methods
- Journal of Computational and Applied Mathematics
- Journal of Manufacturing Processes
- Journal of Materials Processing Technology
- Journal of Mechanical Engineering
- Journal of Production Engineering
- Manufacturing Letters
- Materials & Design
- Materials and Manufacturing Processes
- Materials Science & Engineering A
- Mechanics of Materials
- Simulation Modelling Practice and Theory
- Surface and Coatings Technology
- The International Journal of Advanced Manufacturing Technology

4.4 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
- Scientific Council of the European Research Council (ERC)
- STS Council – Science and Technology in Society Forum, Japan
- Member of the Supervisory Board „Haus der Zukunft e. V."
- Advisory Committee Japan Science and technology Agency (JST) Tokyo
- Board of Trustees, Max Planck-Institute of Molecular Cell Biology and Genetics, Dresden

University Advisory Boards

- Member of the University Council, Johann Wolfgang Goethe-University, Frankfurt (Chairman)
- Member of the University Council, TU Dresden
- Member of the University Council, Bremen University
- Board of Trustees, TU Berlin

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

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
- „Zwanzig20 – Partnerschaft für Innovation“, Funding Program of the Federal Ministry of Education and Research (BMBF), Chairman of the Jury/Expert Group
- Chairman of the Jury of MINTernational, Stifterverband für die Deutsche Wissenschaft e. V.
- Member of the Jury of the Holtzbrinck Publishing Group 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

Senat Memberships

- MPG – Max-Planck-Gesellschaft
- HGF – Helmholtz-Gemeinschaft
- DFG – Deutsche Forschungsgemeinschaft (Guest)

International Exchange

05

5 International Exchange

Prof. Wojciech Z. Misiolek

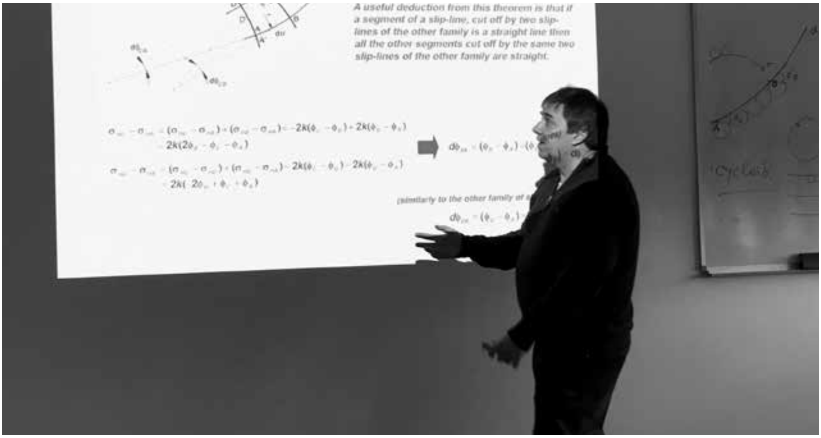
From June 1 to August 14 2015, Professor Wojciech Z. Misiolek of the Institute for Metal Forming (IMF) at the Lehigh University (PA, USA) supported the bulk metal forming group of the IUL as a Mercator visiting professor with his knowledge in the area of microstructure development of aluminum and magnesium alloys. This research stay was funded by the German Research Foundation and was his second visit within this program. During a short-term visit, Alison Kuelz, one of the students of Prof. Misolek, had the chance to join the bulk metal forming group as well and to support Prof. Misiolek's research activities. The intense collaboration with different colleagues of the bulk metal forming group resulted in joint publications and research articles which will be presented at international conferences. In addition, Prof. Misiolek gave a talk to students and scientists on the application and restriction of the additive manufacturing technology for metals.

Prof. Wojciech Z. Misiolek during his talk on additive manufacturing

Prof. Paulo António Firme Martins

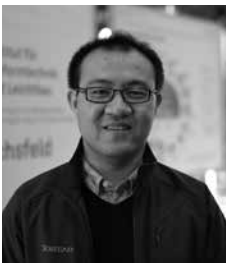
Prof. Paulo Martins from the Instituto Superior Técnico of the Technical University of Lisbon, Portugal, was working as a guest scientist at the IUL from September 1 until November 27, 2015.
As one of the leading researchers in the field of incremental sheet forming, he supported the subprojects A4 and C4 of the Collaborative Research Center/Transregio 3 (DFG – German Research Foundation). With the aim of

producing load-adapted functional components, he focused on the description of the three-dimensional material flow and crack modeling in sheet-bulk metal forming. Due to the complex states of stresses and strains in the forming zone, a complementary use of experimental, numerical, and analytical approaches was necessary. In addition, he worked on studies to determine the formability of sheet metals by means of fracture curves. As a result, an alternative method for the determination of forming limit diagrams and fracture criteria is available. Furthermore, Prof. Martins gave lectures on analytical process evaluations using the slip-line method to train the IUL staff and students in this field of analytical methods.



Prof. Paulo António Firme Martins

Prof. Chengxi Lei


Prof. Chengxi Lei

Dr. Chengxi Lei is an associate Professor at the School of Mechatronic and Engineering (SME) at Harbin Institute of Technology (HIT, China). His stay is funded by the China Scholarship Council (CSC) to collaborate with the IUL as a visiting scholar in the Department of Sheet Metal Forming from September 2015 until September 2016. His research mainly focuses on the field of hot stamping and tube bending. He has built a new constitutive model of 22MnB5 at elevated temperatures with strain rate, temperature and thickness dependency and presented a ductile fracture criterion considering strain rates and temperatures to predict the fracture in hot stamping processes in his PhD thesis. During his stay at the IUL he will extend these models in order to analyze and model the formability of Tailor Rolled Blanks (TRB) made of 22MnB5 in press hardening.


Daeyong Kim, Ph.D.

Dr. Daeyong Kim

Daeyong Kim, senior researcher at the Korea Institute of Materials Science (KIMS), visited the IUL for a three-month research stay from June 8 to September 4, 2015. As an approved expert in the field of material characterization, Mr. Kim supportes the department of Non-Conventional Processes. His work mainly focused on the development of inverse strategies for the determination of temperature and strainrate-dependent material data using the electromagnetic ring expansion test. Additionally, the numerical models for a time-efficient simulation of the ring expansion processes developed by Mr. Kim represent an important instrument for the design of a ring expansion setup stand at the IUL.

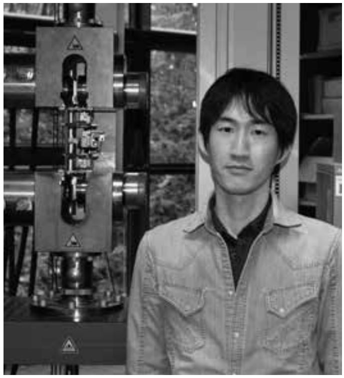

Dr. Yanshan Lou

Alexander von Humboldt Scholar Dr. Yanshan Lou

Dr. Yanshan Lou developed novel anisotropic fracture criteria for ductile sheet metals during his stay at the IUL from September 2014 until August 2015. He is known as an expert in this field due to his previous research which was conducted at the Korean Advanced Institute of Science and Technology as doctoral student and as post-doc at Swinburne University of Technology, Australia, together with Prof. Jeong Whan Yoon. In further research he investigated the correlation between the evolution of the microstructure at the fracture surface and the stress state, in particular for shear-dominated stress states. Dr. Lou co-operated closely with the Department of Applied Mechanics and other members of the IUL. Dr. Lou was accompanied by his wife and two daughters and returned to his home country, China, after his stay.

Mr. Satoshi Sumikawa

Mr. Satoshi Sumikawa, a researcher from JFE Steel Corporation in Japan, is working at the IUL in the sheet metal forming group as a visiting researcher since October 2015 and his stay will last until October 2017. His research topic covers the analysis of material behavior during unloading and high strain deformation under various stress states. He will carry out various material tests such as bulge tests, plane strain tension tests, shear tests, and torsion tests in order to clarify the correlation between stress states and material behavior. Finally, the impact of the material behavior on the sheet metal forming analysis will be investigated by press forming tests and finite element simulations. Mr. Sumikawa is also a PhD Student at Hiroshima University and his works at the IUL will serve as a basis of his PhD thesis.



Mr. Sumikawa in the IUL's laboratory

RISE (Research Internships in Science and Engineering) – Robert Gawrylo and Victor Sullivan

Robert Gawrylo (left) and Victor Sullivan (right) in the IUL's laboratory

From June until August 2015, Robert Gawrylo from the Illinois Institute of Technology and Robert Sullivan from Polytechnique Montréal visited the IUL. Their stay was organized within the framework of the RISE program of the German Academic Exchange Service (DAAD). The program gives Bachelor students from North America and the UK the opportunity to do a three-month internship at German research institutions. The stay of Mr. Gawrylo was financed by a joint scholarship of the DAAD and the DFG Collaborative Research

Center Transregio 73. Mr. Gawrylo was supervised by Mr. Sieczkarek and gained insights into the technology of sheet-bulk metal forming (SBMF). His activities included experimental and metallurgical examinations on the local in-plane rolling process on sheets with the objective of a defined material thickening. Under supervision of Mr. Lueg-Althoff, Mr. Sullivan was engaged in research related to joining of aluminium and steel tubes by magnetic pulse welding. Using experimental and numerical methods, he investigated the deformation behavior of the outer joining part.

G-CADET International Exchange Program with Gifu University

A cooperation agreement to further the studies of students and the faculties involved through exchange programs between Gifu University, Japan, and TU Dortmund University opened the opportunity to exchange excellent master students of the Faculty of Engineering (Gifu University) and the Faculty of Mecanical Engineering (TU Dortmund University). Within this scope, Mr. Yoshki Sakai, a student of the Gifu University, stayed at the IUL in Dortmund

Yoshki Sakai in the Lab

from October 5 to December 4, 2015. He did research on the ring compression test to determine friction coefficients of different lubricants. During his stay he was supervised by Mr. Tobias R. Ortelt, project manager of the ELLI project. At the same time, two students of the TU Dortmund University, Mr. Daniel Pajonk and Mr. Johannes Gebard, stayed at the Gifu University to do research.

More over, the IUL welcomed the following international students in 2015:

- Chiranshu Mukesh Agarwal, IIT Bombay
- Chitrang Bohra, IIT Bombay
- Brittany Ilardi, Princeton University
- Alison Kuelz, Lehigh University

Technical Equipment

06

6 Technical Equipment

6.1 Experimental Area

Presses

- Hydraulic drawing press, 2600 kN, triple action, SMG HZPUI 260/160-1000/1000
- Extrusion press 2,5 MN, Collin, PLA250t
- 10 MN (direct) extrusion press, suitable for curved profile extrusion, SMS Meer
- C-frame-eccentric press, 630 kN, Schuler PDR 63/250
- Hydraulic drawing press, 1000 kN, HYDRAP HPSZK 100-1000/650
- Hydraulic drawing press, 10 MN triple action, M+W BZE 1000-30.1.1
- Press for working media based sheet metal forming, 100 MN, SPS
- Blanking- and forming press with servo drive, 4000 kN, Schuler MSD2-400

Further Forming Machines

- Swivel bending machine, FASTI 2095
- Press brake, 1300 kN, TrumaBend V 1300X
- Three-roller bending machine, FASTI RZM 108-10/5.5
- Three-roll bending machine, Irle B70 MM
- Three-roll bending machine, Roundo R-2-S Special
- Profile bending machine TSS-3D
- Profiling machine RAS 24.10, Reinhardt Maschinenbau GmbH, Sindelfingen
- Roller spinning machine, Bohner & Köhle BD 40
- Spinning machine, Leifeld APED 350NC, CNC Siemens 840 D
- Machine for electromagnetic forming, 1,5 kJ, PPT SMU 1500
- Machine for electromagnetic forming, 6 kJ, Poynting SMU 0612 FS
- Machine for electromagnetic forming, 32 kJ, Maxwell Magneform 7000
- Multi-axes forming press TR 73, 100 kN,

prototype with five axes of motion (Schnupp Hydraulik)

- Hydraulic punching machine TruPunch 5000, 220 kN, RUMPF Werkzeugmaschinen GmbH & Co. KG
- Machine for Incremental Tube Forming, IRU2590, transfluid Maschinenbau GmbH
- Machine for Incremental Profile Forming
- DMU 50 – 5-Axis-millingmaschine, DMG Mori Seiki Academy GMBH

Material Testing Machines

- Bulge-testing machine, 200 kN, Erichsen 142/20
- four Universal testing machines, Zwick 1475 100 kN, Zwick SMZ250/SN5A, Zwick FR250SN.A4K, Allround Line, Zwick Z250
- Sheet metal testing machine Zwick BUP1000
- Plastometer, IUL 1 MN
- Zwick Roell Z250 universal testing machine

Measurement Technique and Electronics

- Laser based Photon-Doppler Velocimeter for the measurement of high workpiece velocities
- Optical frequency domain reflectometer ODiSI-B10 from Luna Technologies. System for the space- and time-resolved measurement of temperature and strain
- Large volume SEM, Mira XI by Visitec (in cooperation with the “Institut für Spanende Fertigung” and “Lehrstuhl für Werkstofftechnologie, TU Dortmund University)
- 3D-coordinate measurement machine, Zeiss PRISMO VAST 5 HTG (in cooperation with the “Institut für Spanende Fertigung”, TU Dortmund University)
- Residual stress measurement devices using borehole method
  - High-speed procedure
  - Air-abrasive procedure
- Hardness testing device, Wolpert Diatestor 2 RC/S
- Thickness measuring device, Krautkrämer CL 304
- 4-channel-digital-oscilloscope, Tektronix TDS 420A
- 3D-video measuring system, Optomess A250

- Infrared measuring device, PYROSKOP 273 C
- GOM: Argus, Atos, Tritop, 3 x Aramis – optical measuring systems for geometry and strains
- High-speed camera, HSFC pro of the company PCO Computer Optics GmbH
- Light optical microscope AxioImager.M1m adapted for polarization, Zeiss AG
- Laser Surface Velocimeter (LSV): non-contact velocity measurement
- Multi-wavelength pyrometer, Williamson pro 100 series
- Keyence Laser: non-contact distance measurement
- X-ray diffractometer for measuring residual stresses – StressTech Xstress 3000
- Pontos 4M, GOM, dynamic 3D analysis, solution 2358 x 1728 pixel
- ARAMIS 4M, GOM, optical 3D-deforming analysis
- Infrared Camera, Infratec VarioCam HD head 680 S / 30 mm, Resolution 1280 x 960 Pixel
- GOM ATOS Triple Scan - 3D scanner
- GOM Aramis 4M Optical 3D deformation analyser
- Prism - Residual stress measurement based on hole-drilling and ESPI

- **Miscellaneous**
- Laser processing center, Trumpf LASERCELL TLC 1005
- Plastic injection molding machine, Arburg Allrounder 270 C 400-100
- Roll seam welding machine, Elektro-Schweißtechnik Dresden UN 63 pn
- Turning machine, Weiler Condor VS2
- different machines for machining purposes
- High-performance metal circular saw, Häberle AL 380
- Belt grinding machine, Baier PB-1200-100S
- Borehole device, Milling Guide RS 200
- Etching and polishing station – LectoPol-5, Struers GmbH
- Industrial robot KUKA-KR 5 sixx R650, 6-axes robot
- Industrial robot KUKA KR 30-3
- Three hydraulic power units and pressure intensifiers up to 4000 bar
- Hydrostatic roller burnishing tool, Ecoroll, HG13 and HG6

- Measuring rack, Boxdorf HP-4-2082
- Combined 5-axis-machining and laser deposition welding center Lasertec 65 3D, Sauer GmbH/DMG Mori

6.2 Hardware and Software Equipment

General Equipment

- different Servers and approx. 220 networked workstation PCs with an extensive periphery
- Linux Cluster with 4 nodes with altogether 12 processing units
- diverse Microsoft Software (Windows 7/8 Professional, Office 2010 Professional etc.)
- diverse graphics software (such as Adobe-products like Photoshop, Acrobat, InDesign, Illustrator and Corel Designer X4)
- diverse High-End simulation PCs for CAD and FEM simulations

CAD

- Unigraphics
- Catia
- AutoCad
- Mechanical Desktop

Mathematical Calculation Programs

- Maple
- Mathcad
- Matlab

FEM

- Pam Stamp
- Autoform
- Hyperworks/HyperXtrude
- Deform
- Simufact
- MSC MARC
- ANsys
- Abaqus
- LS-Dyna

Kooperationen | Cooperations

07

Kooperationen | Cooperations

Auf diesem Wege möchten wir uns für die vielfältige Zusammenarbeit im Jahr 2015 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 2015 which have added to our joint success.

Industriebeirat des IUL | IUL Industrial Advisory Board

Das Gremium des Industriebeirates vermittelte auch im Jahr 2015 wichtige Impulse hinsichtlich des industriellen Forschungsbedarfes. An dieser Stelle möchten wir uns für diese wertvolle Zusammenarbeit bedanken.

In 2015, 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.

- Adolf Edler von Graeve, KIST Kompetenz- und Innovationszentrum für die StanzTechnologie Dortmund e. V.
- Marius Fedler, Kunststoff-Institut für die mittelständische Wirtschaft NRW GmbH
- Dr. Frank O. R. Fischer, Deutsche Gesellschaft für Materialkunde e. V.
- Wolfgang Heidrich, GDA - Gesamtverband der Aluminiumindustrie e. V.
- Jörg Ihne, Otto Fuchs KG
- Franz Jurt, Feintool Technologie AG
- Dr. Stefan Keller, Hydro Aluminium Rolled Products GmbH
- Dr. Lutz Keßler, ThyssenKrupp Steel Europe AG
- Dr. Hansjörg Kurz, Volkswagen Aktiengesellschaft
- Nico Langerak, Tata Steel Research & Development
- Prof. Gideon Levy, TTA – Technology Turn Around
- Franz-Bernd Pauli, Franz Pauli GmbH & Co. KG
- Dr. Heinz-Jürgen Prokop, TRUMPF Werkzeugmaschinen GmbH & Co. KG
- Dr. Hendrik Schafstall, simufact engineering GmbH
- Dr. Johannes Henrich Schleifenbaum, PHOENIX FEINBAU GmbH & Co. KG
- Dr. Joachim Schondelmaier, Schondelmaier GmbH
- Prof. Karl Schweizerhof, DYNAmore GmbH
- Dr. Hosen Sulaiman, Faurecia Autositze GmbH
- Sabine Widdermann, German Cold Forging Group (GCFG)
- Dr. Hans-Joachim Wieland, Stahlinstitut VDEh

Universitäre Kooperationen auf nationaler Ebene | University cooperations at national level

- Fachgebiet Maschinenelemente, Technische Universität Dortmund
- Fachgebiet Werkstoffprüftechnik, Technische Universität Dortmund
- Institut für Mechanik, Technische Universität Dortmund

- Institut für Spanende Fertigung, Technische Universität Dortmund
- Lehrstuhl für Werkstofftechnologie, Technische Universität Dortmund
- Zentrum für HochschulBildung, zhb, Technische Universität Dortmund
- Chair of Micromechanical and Macroscopic Modelling, ICAMS, Ruhr-Universität Bochum
- Fachbereich Produktionstechnik, Universität Bremen
- FH Südwestfalen
- fka Forschungsgesellschaft Kraftfahrwesen mbH Aachen, Rheinisch-Westfälische Technische Hochschule Aachen
- Fraunhofer-Institut für Werkstoff- und Strahltechnik IWS, Dresden
- Fraunhofer-Institut für Werkzeugmaschinen und Umformtechnik, IWU, Technische Universität Chemnitz
- Fraunhofer-Projektgruppe im Dortmunder Oberflächen-Centrum (DOC) der TKSE AG, Dortmund
- Gemeinschaftslabor für Elektronenmikroskopie, Rheinisch-Westfälische Technische Hochschule Aachen
- Institut für Angewandte Mechanik, Rheinisch-Westfälische Technische Hochschule Aachen
- Institut für Bildsame Formgebung, Rheinisch-Westfälische Technische Hochschule Aachen
- Institut für Fertigungstechnik und Werkzeugmaschinen, Leibniz Universität Hannover
- Institut für Formgebende Fertigungstechnik, Technische Universität Dresden
- Institut für Kunststoffverarbeitung, Rheinisch-Westfälische Technische Hochschule Aachen
- Institut für Leichtbau und Kunststofftechnik, Technische Universität Dresden
- Institut für Massivbau, Technische Universität Dresden
- Institut für Mechanik der Bauwissenschaften, Universität Duisburg-Essen
- 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 Umformtechnik, Universität Stuttgart
- Institut für Umformtechnik und Umformmaschinen, Leibniz Universität Hannover
- Institut für Werkstoffkunde I, Karlsruher Institut für Technologie (KIT)
- Institut für Werkstoffkunde, Leibniz Universität Hannover
- Institut für Werkzeugmaschinen und Betriebswissenschaften, Technische Universität München
- Institutscluster IMA/ZLW & IfU (Lehrstuhl für Informationsmanagement im Maschinenbau & Zentrum für Lern- und Wissensmanagement), Rheinisch-Westfälische Hochschule Aachen

- Labor für Fahrwerktechnik, Hochschule Osnabrück
- Laboratorium für Werkstoff- und Fügetechnik, Universität Paderborn
- Lehrstuhl für Fertigungstechnologie, Friedrich-Alexander-Universität Erlangen-Nürnberg
- Lehrstuhl Fertigungstechnik, Universität Duisburg-Essen
- Lehrstuhl für Feststoffverfahrenstechnik, Ruhr-Universität Bochum
- Lehrstuhl für Konstruktion und Fertigung, Brandenburgische Technische Universität Cottbus
- Lehrstuhl für Leichtbau, Technische Universität München
- Lehrstuhl für Umformende und Spanende Fertigungstechnik, Universität Paderborn
- Lehrstuhl für Umformtechnik und Gießereiwesen, Technische Universität München
- Lehrstuhl für Umformtechnik, Universität Siegen
- Lehrstuhl für Werkstoffkunde, Universität Paderborn
- Max-Planck-Institut für Eisenforschung GmbH, Düsseldorf
- Professur für Baumechanik, Universität der Bundeswehr München
- Professur Theoretische Elektrotechnik und Numerische Feldberechnung, Helmut-Schmidt-Universität, Universität der Bundeswehr Hamburg
- Professur Virtuelle Fertigungstechnik, Technische Universität Chemnitz
- wbk Institut für Produktionstechnik, Karlsruher Institut für Technologie (KIT)
- Werkzeugmaschinenlabor, Rheinisch-Westfälische Technische Hochschule Aachen

Universitäre Kooperationen auf internationaler Ebene | University cooperations at international level

- Charles Delaunay Institute, Labarotoire des Systèmes Mécaniqueset d'ingénierie Simultanée (LASMIS), Université de Technologie de Troyes, France
- Department of Mechanical and Systems Engineering, Gifu University, Yanagido, Japan
- Department of Materials Science and Engineering, The Ohio State University, Ohio, USA
- Department of Mechanical Engineering, Instituto Superior Técnico, University of Lisbon, Portugal
- Department of Mechanical Engineering, Section of Manufacturing Engineering, Danmarks Tekniske Universitet, Lungby, Denmark
- Department of Mechanical Science and Engineering, Hiroshima University, Higashi-Hiroshima, Japan
- Ecole nationale Supérieure d'Arts et Métiers (ENSAM), ParisTech, Paris, France
- Forming Laboratory, Faculty of Mechanical Engineering, University of Ljubljana, Ljubljana, Slovenia
- Harbin Institute of Technology, School of Mechatronics Engineering, Harbin, Heilongjiang, P. R. China
- Institut Carnot ARTS, Université de Valenciennes et du Hainaut Cambrésis, Valenciennes, France

- Institute for Manufacturing, Department of Engineering, University of Cambridge, Great Britain
- KAIST - Korea Advanced Institute of Science and Technology, Daejeon, Republic of Korea
- KIMS - Korea Institute of Materials Science, Gyeongnam, Republic of Korea
- Laboratory of Physics and Mechanics of Materials, Arts et Métiers ParisTech (Metz Campus), France
- Loewy Chair in Materials Forming and Processing, Institute for Metal Forming, Lehigh University, Bethlehem, Pennsylvania, USA
- Mechanical Engineering College of Tongji University, Jiading Campus, Shanghai, P. R. China
- Nagoya University, Nagoya, Japan
- Technological Institute, Robert, R. McCormick School of Engineering and Applied Science, Evanston, USA
- Türkisch-Deutsche Universität, Istanbul, Turkey
- Universitatea Babeş-Bolyai, Cluj-Napoca, Romania

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

- Aleris Aluminum Duffel BVBA
- alutec metal innovations GmbH & Co. KG
- ASCAMM Technology Centre
- ASERM – Asociación Española de Rapid Manufacturing
- AUDI AG
- Auerhammer Metallwerk GmbH
- AutoForm Engineering GmbH
- Becker Apparatebau
- Benteler AG
- Bilstein GmbH & Co. KG
- BMW AG
- borit Leichtbau-Technik GmbH
- Böhler-Uddeholm Deutschland GmbH
- Carl Bechem GmbH
- C-TEC Constellium Technology Center
- CRF – Centro Ricerche Fiat S.C.p.A.
- Daimler AG
- Data M Sheet Metal Solutions GmbH
- Deutsche Edelstahlwerke GmbH
- DYNAmore GmbH
- EADS Deutschland GmbH
- ESI GmbH
- F.W. Brökelmann Aluminiumwerk GmbH & Co. KG
- Faurecia Group
- Forming Technology Research Department, Steel Laboratory, JFE Steel Company, Chiba, Japan
- Forschungsvereinigung Stahlanwendung e. V. (FOSTA)

- Franz Pauli GmbH & Co. KG
- FRIMO Group GmbH Composites & Tooling Technologies
- Grundfos GmbH
- GSU-Schulungsgesellschaft für Stanz- und Umformtechnik mbH
- HELLA KGaA Hueck & Co.
- Hirschvogel Umformtechnik GmbH
- TRUMPF Hüttinger GmbH + Co. KG
- Hydro Aluminium Deutschland GmbH
- inpro Innovationsgesellschaft für fortgeschrittene Produktionssysteme in der Fahrzeugindustrie mbH
- Inspire AG - IRPD
- JRC-ITU Institute for Transuranium Elements, Karlsruhe
- JFE Steel Corporation, Japan
- Johnson Controls Hilchenbach GmbH
- Josef Fröhling GmbH & Co. KG
- Kirchhoff Automotive GmbH
- Kistler Instrumente AG
- KODA Stanz- und Biegetechnik GmbH
- KraussMaffei Group GmbH
- Kunststoff-Institut Lüdenscheid GmbH
- LG Corporation
- LEIBER Group GmbH & Co. KG
- MatFEM
- MUBEA Unternehmensgruppe
- Otto Fuchs KG
- Poynting GmbH
- Premium AEROTEC GmbH
- Rehau AG + Co
- S+C Extrusion Tooling Solutions GmbH
- Salzgitter Mannesmann Forschung GmbH
- Salzgitter Mannesmann Präzisrohr GmbH
- Schnupp GmbH & Co. Hydraulik KG
- Schondelmaier GmbH
- Schuler AG
- Schwarze-Robitec GmbH
- Simufact Engineering GmbH
- SimuForm GmbH
- SMS Meer GmbH
- Société Tuniesienne des filtres (MISFAT), Jedeida, Tunesia
- Sparkasse Dortmund
- SSAB Swedish Steel GmbH
- SSAB Tunnplåt AB, Schweden
- Tata Steel
- Tata Steel Strip Products UK
- TECOS – Slovenian Tool and Die Development Centre
- ThyssenKrupp Nirosta GmbH
- ThyssenKrupp Steel Europe AG
- ThyssenKrupp VDM GmbH

- TRACTO-TECHNIK GmbH & Co. KG Spezialmaschinen
- Transfluid Maschinenbau GmbH
- TRUMPF Hüttinger GmbH + Co. KG
- TRUMPF Werkzeugmaschinen GmbH + Co. KG
- Viessmann Werke GmbH & Co. KG
- voestalpine AG
- VOLKSWAGEN AG
- Vorrichtungsbau Giggel GmbH
- Vossloh AG
- Welser Profile GmbH
- Westfalia Presstechnik GmbH & Co. KG
- Wilke Werkzeugbau GmbH & Co. KG
- WILO SE
- Zentrum für BrennstoffzellenTechnik GmbH

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.
- 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
- JSTP – The Japan Society for Technology of Plasticity
- KIST Kompetenz- und Innovationszentrum für die StanzTechnologie Dortmund e. V.
- Stahlinstitut VDEh
- VDI Verein Deutscher Ingenieure e. V.
- WGP – Wissenschaftliche Gesellschaft für Produktionstechnik

Stiftungen | Foundations

- KARL-KOLLE-Stiftung
- VolkswagenStiftung
- Werner Richard - Dr. Carl Dörken Stiftung
- Wilo-Foundation

Abgeschlossene Arbeiten | Completed Theses

08

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

Ahmad, Ashar
Tekkaya, A. E. • Hess, S.
Untersuchungen zum Einsatz von Stahlkugeln zur Umformung von rohrförmigen Komponenten als Alternative zum hydraulischen Fluid
Investigation of using steel balls as an alternative for hydraulic fluid for the forming of tubular hydroforming parts

Anbazhagan, Vijayasarathy
Tekkaya, A. E. • Staupendahl, D. • Heuse, M. (Faurecia)
Untersuchung des Einflusses der Kantenrissempfindlichkeit auf das Formänderungsvermögen von höchstfesten Stählen
Investigation of the influence of the crack sensitivity at cut edges on the formability of advanced high strength steels

Aragon Jimenez, Luis Alan
Tekkaya, A. E. • Hess, S. • Chatti, S.
Ermittlung der Glühparameter zur Erweiterung des Umformvermögens ferritischen Edelstahls
Determination of annealing parameters for extended formability of ferritic stainless steel

Fabela Guardado, Adrian
Tekkaya, A. E. • Hess, S.
Warmumformung ferritischer Edelstahlrohre unter Einsatz von Stahlkugeln als Umformmedium - experimentelle und numerische Analyse
Hot forming of tube made of ferritic stainless steel using steel balls as forming media – experimental and numerical analysis

Gauhar, Nasim
Tekkaya, A. E. • Chatti, S. • Löbbe, C.
Numerische Simulation eines Mehrschritt-J-Biegeverfahrens zur Herstellung von längsnahtgeschweißten Rohren
Numerical approach to model a multistage J-step bending process for the manufacturing of LSAW pipes

Ghanekar, Abhishek
Brands, D. (Universität Duisburg-Essen) • Bluhm, J. (Universität Duisburg-Essen) • Tekkaya, A. E. • Schwane, M.
Simulation und Sensitivitätsanalyse der Modellierungsparameter am Beispiel der Extrusion Benchmark Versuche 2013
Simulation and sensitivity analysis of modeling parameters with regard to Extrusion Benchmark trials 2013

Gutierrez, Antonio
Tekkaya, A. E. • Dang, T.
Untersuchung zur inkrementellen Blechumformung mit komprimiertem Gegendruck
Studies of single point incremental forming with back support pressurized fluid

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

Hering, Oliver
Tekkaya, A. E. • Löbbe, C.
Untersuchung hochfester Stähle hinsichtlich ihres Potentials zur Einstellung mechanischer Eigenschaften beim schnellgetakteten Warmumformen
Potential of high strength steels for the adjustment of mechanical properties in rapid hot forming processes

Hoppe, Christoph
Tekkaya, A. E. • Löbbe, C.
Entwicklung einer totzeitbehafteten Regelung zur Rückfederungskompensation beim Folgeverbundbiegen mittels Online-Winkelmessung
Springback compensation in a progressive die based on closed loop control with an online geometry feedback

Hosseini, Mohamad
Tekkaya, A. E. • Chatti, S. • Mennecart, T.
Untersuchungen zur Nutzung festigkeitsadaptierter, segmentierter Werkzeuge für die Umformung von Tailor Welded Blanks
Investigations about the use of segmented and strength adjusted tools for the forming of tailor welded blanks

Ködel, Henning Christian
Tekkaya, A. E. • Staupendahl, D. • Chatti, S.
Anpassung des Prozesssimulationsmodells für das TSS (Torque Superposed Spatial) Biegen an eine modulare Vorschubachse
Modification of the process simulation model for TSS (Torque Superposed Spatial) bending to incorporate a modular feeding axis

Manzoor, Anus
Tekkaya, A. E. • Staupendahl, D. • Mertens, O. (ThyssenKrupp Steel Europe AG) • Kibben, M. (ThyssenKrupp Steel Europe AG)
Untersuchung der Auswirkung von Werkzeugbewegungen des ThyssenKrupp-Biegeprozesses auf die Konturen freiformgebogener Profile
Studies on the effect of tool positioning on free-form bent profiles using the ThyssenKrupp bending procedure

Nazari, Esmaeil
Tekkaya, A. E. • Staupendahl, D. • Großpietsch, D. (Salzgitter Mannesmann Precesion GmbH)
Analyse der Wärmebehandlung von lufthärtenden Stählen für die In-Line-Anwendung beim Induktionsbiegen
In-Line heat treatment of air-hardening steel for the Implementation in induction bending

Rosinski, Daniel
Tekkaya, A. E. • Pelster, H. (SMS group GmbH) • Dahnke, C.
Energetische Analyse der Prozesskette einer Leichtmetallstrangpresse bei direkter Verfahrweise
Energetic analysis of the process chain of a direct extrusion press for the processing of light metals

Schmitz, Fabian
Tekkaya, A. E. • Clausmeyer, T. • Isik, K.
Bestimmung und Analyse von Versagenskriterien in der Blechumformsimulation
Determination and analysis of failure criteria for sheet metal forming simulations

Selvanatarajan, Vignesh
Tekkaya, A. E. • Staupendahl, D.
Entwicklung eines Prozessregelsystems für die Steuerungssoftware der TSS-Profilbiegemaschine
Development of a closed-loop control system for the motion control software of the TSS profile bending machine

Thota, Vinesh
Tekkaya, A. E. • Ortelt, T. R.
Automatisierung des Nakajima-Versuchs mithilfe eines optischen Messsystems und eines Roboters zur Bestimmung von Grenzformänderungskurven
Automation of the Nakajima test using an optical measuring system an a robot to determine forming limit curves

Traphöner, Heinrich
Tekkaya, A. E. • Güner, A. • Yin, Q.
Identifikation der kinematischen Verfestigung mit dem ebenen Torsionsversuch
Identification of kinematic hardening using the in-plane torsion test

Üstünyagiz, Esmeray
Tekkaya, A. E. • Lueg-Althoff, J.
Der Titel unterliegt der Schweigepflicht.
The title is subject to confidentiality.

Zhang, Shunyi
Tekkaya, A. E. • Lueg-Althoff, J.
Magnetpulsschweißen mittels elektromagnetischer Kompression: Experimentelle und numerische Untersuchung von Prozessparametern
Magnetic pulse welding by electromagnetic compression: experimental and numerical investigation of process parameters

Abgeschlossene Diplomarbeiten | Completed Diploma Theses for the former Dipl.-Ing. Degree

Ben Soltana, Ibrahim
Tekkaya, A. E. • Steinbach, F. • Chatti, S.
Untersuchung des Verschleißes beim schmierstofffreien Schneiden von Blechen
Investigation of wear in lubricant-free shear cutting of sheets

El Fessi, Mounir
Tekkaya, A. E. • Völlmecke, J. (Faurecia) • Staupendahl, D. Chatti, S.
Prozessentwicklung zum umformtechnischen Fügen von Flanschen an Rohre mit unterschiedlichen Durchmessern am Beispiel eines Sitzhöhenverstellersystems
Design of a forming process for joining flanges to tubes with varying diameters using the example of seat recliner mechanism

Kessling, Andreas
Tekkaya, A. E. • Schwane, M.
Experimentelle Untersuchung des Einflusses der Strangpresswerkzeuggeometrie auf die Längspressnahtqualität
Experimental investigation of the influence of the extrusion die design on the longitudinal seam weld quality

Ye, Jun
Tekkaya, A. E. • Hess, S.
Umformtechnische Betrachtung eines im Spritzgießwerkzeug kombinierten Tiefzieh- und Hinterspritzprozesses
Consideration of a combinated process of deep drawing and injection moulding realised in one tool

Zhang, Yunxuan
Tekkaya, A. E. • Staupendahl, D. • Sieczkarek, P.
Kinematische Bewegungsanalyse der Mehrachspresse - Modellierung und experimentelle Validierung
Kinematic motion analysis of the multi-axis forming press - Modelling and experimental validation

Abgeschlossene Bachelorarbeiten | Completed Bachelor of Science Theses

Altuntas, Ahmet
Tekkaya, A. E. • Chatti, S. • Sieczkarek, P.
Entwicklung und Konstruktion einer adaptiven Vorrichtung für das lokale Aufdicken sowie das umformtechnische Ausformen von Verzahnungen an Napfzargen und Rohrwandsegmenten mittels inkrementeller Blechmassivumformung
Development and Construction of an adaptive fixture for the local thickening and the shaping of gears by forming on cup walls or tube segments with the incremental sheet-bulk metal forming

Dahm, Moritz
Tekkaya, A. E. • Chatti, S. • Clausmeyer, T. • Gutknecht, F.
Sensitivitätsanalyse für die Materialparameter des Gurson-Tvergaard-Needleman-Modells
Sensitivity analysis for the material parameters of the Gurson-Tvergaard-Needleman model

Gebhard, Johannes
Tekkaya, A. E. • Chatti, S. • El Budamusi, M. • Clausmeyer, T.
Numerische Untersuchung zur Prozessoptimierung hochfester Stahlwerkstoffe beim Frei- und Druckbiegen
Numerical investigation for the process optimization of high strength steels in the context of air and pressure bending

Häußler, Helge Michael
Tekkaya, A. E. • Ortelt, T. R.
Experimentelle Untersuchung zur Reproduzierbarkeit und Charakterisierung von Einflussfaktoren von Blechumformprüfmaschinen
Experimental investigation of the reproducibility and characterization of influencing factors of sheet metal testing machines

König, Eva Maria
Tekkaya, A. E. • Staupendahl, D.
Konstruktion und Auslegung einer elektromechanischen Zusatzachse für die TSS-Profilbiegemaschine zur Einstellung des Hebelarms während des Biegeprozesses
Development and design of an additional electro-mechanical axis for the TSS profile bending machine for the variation of the lever arm during the bending process

Kunze, Justin
Tekkaya, A. E. • Scharfenorth, S. (Giebel Kaltwalzwerk GmbH) Dahnke, C.
Konstruktion und Inbetriebnahme einer Abblasung und Bandkantenabsaugung zur definierten Emulsionsschichtdickenbestimmung beim Kaltwalzen
Construction and implementation of a device for the defined removal of the emulsion layer in the cold rolling process

Möller, Christian
Tekkaya, A. E. • El Budamusi, M. • Dang, T.

Untersuchung des Umformverhaltens höherfester Stahlwerkstoffe bei Biegeumformprozessen
Investigation of the forming behaviour of high strength steel in bending processes

Ortelt, Dominik Markus
Tekkaya, A. E. • Chatti, S. • Hiegemann, L.
Entwicklung und Konstruktion eines Glattwalzwerkzeugs zur Erhöhung der Bearbeitungsgeschwindigkeit durch Überlagerung der Translations- und Rotationsbewegung einer Fräsmaschine
Development and Construction of a burnishing tool to increase the processing speed by superimposition of the translational and rotational movement of a milling machine

Schilling, Bastian
Tekkaya, A. E. • Lueg-Althoff, J.
Einfluss der Rohrwandstärken auf die Schweißnahtqualität beim Magnetpulsschweißen mittels elektromagnetischer Kompression
Influence of the wall thicknesses of tubular joining partners on joint quality during magnetic pulse welding by electromagnetic compression

von der Mühlen, Jochen
Tekkaya, A. E. • Kloppenborg, T.
Experimentelle und numerische Analyse zum Einfließen einer verunreinigten Blockrandschicht beim Strangpressen
Experimental and numerical analysis of the material flow of the billet skin during extrusion

Weber, Florian
Tekkaya, A. E. • Gutknecht, F.
Untersuchung des Einflusses der Charakterisierung und Modellierung plastischer Eigenschaften auf die Scherschneidsimulation von Dualphasenstählen
Investigation of the impact of plastic properties characterization and modeling on blanking simulation of dual phase steels

Wesselbaum, Jan Erik
Tekkaya, A. E. • Grzancic, G.
Experimentelle Untersuchungen zur Übertragbarkeit analytischer Ansätze zur Beschreibung von Bauteildeformationen auf das Inkrementelle Profilumformen
Experimental investigations on the transferability of analytical approaches for the description of part deformation in Incremental Profile Forming

Abgeschlossene Studienarbeiten | Completed Student Theses for the former Dipl.-Ing. Degree

Bauer, Maik
Tekkaya, A. E. • Selvaggio, A.
Aufbau eines Modellversuchs für das Strangpressen von Profilen mit variablen Wandstärken
Establishment of a model experiment for the extrusion of profiles with variable wall thicknesses

Simkowskij, Roman
Tekkaya, A. E. • Selvaggio, A.
Analyse des Strangpressens von Profilen mit variablen Wandstärken anhand eines Modellversuches
Analysis of the extrusion of profiles with variable wall thicknesses using a model experiment

Tebaay, Lennart Manfred
Tekkaya, A. E. • Dang, T.
Methoden zur Charakterisierung von Sandwichwerkstoffen
Methods for the characterisation of sandwich plates

Abgeschlossene Projektarbeiten | Completed Project Theses

El-Jellouli, Mohamed Amine
Tekkaya, A. E. • Chatti, S. • Clausmeyer, T.
Tiefziehsimulationsprozess zur Rissvorhersage eines komplexen Automobilblechbauteils aus höchstfestem Stahlwerkstoff unter Anwendung eines weiterentwickelten Versagensmodells nach Lemaitre
Simulation of deep drawing for crack prediction of a complex automotive part manufactured from high strength steel with an enhanced Lemaitre damage model

Fabela Guardado, Adrian • Ortega Espin, Andres Roberto
Tekkaya, A. E. • Hess, S.
Hydroumformung walzplattierter Bleche
Hydroforming of cold roll bonded sheets

Grote, Jannik
Tekkaya, A. E. • Staupendahl, D. • Clausmeyer, T.
Experimentelle Ermittlung der Werkstoffkennwerte von Dualphasen- und mikrolegierten Stählen zur numerischen Simulation des Schädigungsverhaltens beim Rückbiegen
Experimental determination of material parameters of dual phase and micro-alloyed steels for the numerical simulation of the damage behavior during reverse bending

Haubert, Ansgar • Kessling, Andreas
Tekkaya, A. E. • Dang, T.
Experimentelle Optimierung der Probengeometrie zur Reduzierung der Streuung
Experimental optimization of the specimen geometry to reduce the scattering

Hoppe, Benjamin
Tekkaya, A. E. • Staupendahl, D.
Untersuchung der sich selbsteinstellenden Biegung und Torsion beim Herstellen von Profilen mit dreieckigen Querschnitten mittels eines dreistufigen Walzprozesses
Analysis of self-twisting and bending of profiles with triangular cross-sections formed by a three-step rolling process

Karczewski, Christian
Tekkaya, A. E. • Chatti, S. • Sieczkarek, P.
Lokales Aufdicken von Blechwerkstoffen mittels Walzen – Erstellen eines numerischen Modells mit Simufact.forming
Local thickening of sheet metals by rolling – generating a numerical model with Simufact.forming

Kolberg, Markus • Köhne, Karsten
Tekkaya, A. E. • El Budamusi, M. • Staupendahl, D.
Konstruktion einer querkraftfreien Biegevorrichtung für eine Zwick-Prüfmaschine
Design of a pure bending test setup for a Zwick universal testing machine

Marohn, Marius
Tekkaya, A. E. • Chatti, S. • Sieczkarek, P.
Spannungsüberlagerung bei der Blechmassivumformung – Entwicklung, Realisierung und Erprobung eines Versuchsstandes
Superposition in Sheet-Bulk Metal Forming - Development, realization and testing of an experimental rig

Nitze, Tobias • Flick, Bastian Janis
Tekkaya, A. E. • Staupendahl, D.
Online-Messung der Biegelinie während des 3-D-Profilbiegens mittels GOM Pontos
Online measurement of the bending line during 3-D profile bending using GOM Pontos

Upadhya, Siddharth • Bobretsova, Anastasia
Tekkaya, A. E. • Staupendahl, D.
Experimentelle und numerische Untersuchung der Dehnungen beim 3D-Profilbiegen
Experimental and numerical investigation of the strain during 3D profile bending

Ausgewählte Veröffentlichungen und Vorträge | Selected Publications and Lectures

09

Zeitschriftenbeiträge | For Journals (Peer Reviewed SCI-Journals)

Ben Khalifa, N., Foydl, A., Pietzka, D., Jäger, A., 2015. Process Limits of Extrusion of Multimaterial Components. Journal of Manufacturing Science and Engineering 137 (5):051001-051001-9.

Chen, H., Güner, A., Ben Khalifa, N., Tekkaya, A. E., 2015. Granular media-based tube press hardening. Journal of Materials Processing Technology. doi: 10.1016/j.jmatprotec.2015.03.028.

Chen, L., Clausmeyer, T., Tekkaya, A. E., 2015. Experimental characterization and numerical modelling of the mechanical behavior of half sandwich laminate in the context of blanking, Computer Methods in Materials Science – Special Issue Komplastech 2015 15, pp. 162-168.

Clausmeyer, T., Svendsen, B., 2015. Comparison of two models for anisotropic hardening and yield surface evolution in bcc sheet steels. European Journal of Mechanics A/Solids 54, pp. 120-131.

Dahnke, C., Foydl, A., Levin, E., Haase, M., Tekkaya, A. E., 2015. Process window for the embedding of eccentric steel-reinforcing elements in the discontinuous composite extrusion process. Applied Mechanics and Materials 794, pp. 182-189.

Duflou, J. R., Tekkaya, A. E., Haase, M., Welo, T., Vanmeensel, K., Kellens, K., Dewulf, W., Paraskevas, D., 2015. Environmental assessment of solid state recycling routes for aluminium alloys: Can solid state processes significantly reduce the environmental impact of aluminium recycling? CIRP Annals - Manufacturing Technology 64, pp. 37-40.

Gies, S., Langolf, A., Weddeling, C., Tekkaya, A. E., 2015. Measurement of working coil temperature in electromagnetic forming processes by means of optical frequency domain reflectometry. Case Studies in Nondestructive Testing and Evaluation 3, pp. 15-20.

Haase, M., Tekkaya, A. E., 2015. Cold extrusion of hot extruded aluminum chips. Journal of Materials Processing Technology 217, pp. 356-367.

Hahn, M., Weddeling, C., Lueg-Althoff, J., Tekkaya, A. E., 2015. Analytical Approach for Magnetic Pulse Welding of Sheet Connections. Journal of Materials Processing Technology. http:// dx.doi.org/10.1016/j.jmatprotec.2015.11.021.

Hahn, M., Weddeling, C., Taber, G., Vivek, A., Daehn, G. S., Tekkaya, A. E., 2015. Vaporizing foil actuator welding as a competing technology to magnetic pulse welding. Journal of Materials Processing Technology. http://dx.doi.org/10.1016/j.jmatprotec.2015.11.010.

Hiegemann, L., Weddeling, C., Ben Khalifa, N., Tekkaya, A. E., 2015. Prediction of roughness after ball burnishing of thermally coated surfaces. Journal of Materials Processing Technology 217, pp. 193-201.

Hölker, R., Tekkaya, A. E., 2015. Advancements in the manufacturing of dies for hot aluminum extrusion with conformal cooling channels. The International Journal of Advanced Manufacturing Technology. pp 1-12

Isik, K., Silva, M. B., Atkins, A. G., Tekkaya, A. E., Martins, P. A. F., 2015. A new test for determining fracture toughness in plane stress in mode II. Journal of Strain Analysis for Engineering Design 50, pp. 221-231.

Li, S. P., Güner, A., Tekkaya, A. E., 2015. Analysis of Drawbead Behaviour for Sandwich Sheets in Sheet Forming Simulation. Applied Mechanics and Materials 794, pp. 59-66.

Löbbe, C., Hoppe, C., Becker, C., Tekkaya, A. E., 2015. Closed Loop Springback Control in Progressive Die Bending by Induction Heating. International Journal of Precision Engineering and Manufacturing 16 (12), pp. 2441-2449.

Silva M. B., Isik, K., Tekkaya, A. E., Martins P. A. F., 2015. Fracture Loci in Sheet Metal Forming: A Review. Acta Metallurgica Sinica (English Letters). Volume 28, Issue 12, pp 1415-1425.

Tekkaya, A. E., Allwood, J. M., Bariani, P. F., Bruschi, S., Cao, J., Gramlich, S., Groche, P., Hirt, G., Ishikawa, T., Löbbe, C., Lueg-Althoff, J., Merklein, M., Misiolek, W. Z., Pietrzyk, M., Shivpuri, R., Yanagimoto, J., 2015. Metal forming beyond shaping: Predicting and setting product properties. CIRP Annals – Manufacturing Technology 64 (2), pp. 629-653.

Ul Hassan, H., Maqbool, F., Güner, A., Hartmaier, A., Ben Khalifa, N., Tekkaya, A. E., 2015. Springback prediction and reduction in deep drawing under influence of unloading modulus degradation. International Journal of Material Forming 15, p. Article in Press. doi: 10.1007/s12289-015-1248-5.

Weddeling, C., Demir, O. K., Haupt, P., Tekkaya, A. E., 2015. Analytical methodology for the process design of electromagnetic crimping. Journal of Materials Processing Technology 222, pp. 163-180.

Weddeling, C., Gies, S., Ben Khalifa, N., Tekkaya, A. E., 2015. Analytical model to determine the strength of form-fit connection joined by die-less hydroforming. Journal of Manufacturing Science and Engineering, Transactions of the ASME 137(5):051014-051014-10.

Weddeling, C., Walter, V., Haupt, P., Tekkaya, A. E., Schulze, V., Weidenmann, K. A., 2015. Joining zone design for electromagnetically crimped connections. Journal of Materials Processing Technology 225, pp. 240-261.

Yin, Q., Soyarslan, C., Isik, K., Tekkaya, A. E., 2015. A grooved in-plane torsion test for the investigation of shear fracture in sheet materials. International Journal of Solids and Structures 66, pp. 121-132.

Yin, Q., Tekkaya, A. E., Traphöner, H., 2015. Determining cyclic flow curves using the in-plane torsion test. CIRP Annals - Manufacturing Technology 64, pp. 261-264.

Yue, Z. M., Soyarslan, C., Badreddine, H., Saanouni, K., Tekkaya, A. E., 2015. Identification of fully coupled anisotropic plasticity and damage constitutive equations using a hybrid experimental-numerical methodology with various triaxialities. International Journal of Damage Mechanics 24 (5), pp. 683-710.

Beiträge in Konferenzbänden | Publications in Proceedings

Becker, C., Tekkaya, A. E.,2015. Wall thickness distribution during a combined tube spinning and bending process. In: Key Engineering Materials 651 - 653, 18^{th} International ESAFORM Conference on Material Forming 2015, Graz, Austria, pp. 1614-1619.

Chatti, S., Weinrich, A., El Budamusi, M., Becker, C., Maevus, F., Tekkaya, A. E., 2015. Influencing the Forming Limits in Air Bending Using Incremental Stress Superposition. In: Key Engineering Materials 651-653, 18^{th} International ESAFORM Conference on Material Forming 2015, Graz, Austria, pp. 1602-1607.

Chen, H., Hess, S., Güner, A., Tekkaya, A. E., 2015. Active and passive granular media-based tube press hardening. In: 10. Erlanger Workshop Warmblechumformung, Meisenbach, Germany, pp. 115-129.

Citrea, T., Dahnke, C., Gagliardi, F., Haase, M., Ambrogio, G., Tekkaya, A. E., 2015. Optimization of Porthole Die for Non-symmetric Composite Profiles. In: Materials Today: Proceedings 2, Aluminium 2000 and International Conference on Extrusion and Benchmark (ICEB), Florence, Italy, pp. 4778-4785.

Dahnke, C., Foydl, A., Levin, E., Haase, M., Tekkaya, A. E., 2015. Process window for the embedding of eccentric steel-reinforcing elements in the discontinuous composite extrusion process. In: Advanced Materials Research, WGP Kongress 2015, Hamburg, Germany, online soon.

Dahnke, C., Hilbring, J., Kloppenborg, T., Haase, M., Tekkaya, A. E., 2015. Investigations for the Embedding of Functional Elements in the Composite Extrusion Process. In: Materials Today: Proceedings 2, Aluminium 2000 and International Conference on Extrusion and Benchmark (ICEB), Florence, Italy, pp. 4763-4770.

Dahnke, C., Selvaggio, A., Haase, M., Tekkaya, A. E., 2015. Developments in Composite Extrusion. In: JSTP International Seminar on Precision Forging (7^{th} ISPF), Nagoya, Japan, pp. 119-122.

El Budamusi, M., Isik, K., Chen, L., Clausmeyer, T., Becker, C., Tekkaya, A. E., 2015. Enhanced Damage Modelling for Sheet Metal Forming of High Strength Steels – Part 2: Application to forming processes. In: 2nd European Steel Technology and Application Days, Düsseldorf, Germany, (CD).

Gamberoni, A., Donati, L., Reggiani, B., Haase, M., Tomesani, L., Tekkaya, A. E., 2015. Process Monitoring and Analysis of Hollow EN AW-6063 Extruded Profile. In: Materials Today: Proceedings 2, Aluminium 2000 and International Conference on Extrusion and Benchmark (ICEB), Florence, Italy, pp. 4714-4722.

Gutknecht, F., Steinbach, F., Clausmeyer, T., Tekkaya, A. E., 2015. Advanced material model for shear cutting of metal sheets. In: Proceedings of COMPLAS XIII, Barcelona, Spain, pp. 170-181.

Grzancic, G., Becker, C., Ben Khalifa, N., Tekkaya, A. E., 2015. Basic Investigations In Incremental profile Forming. MSEC2015, Charlotte, North Carolina, US. doi:10.1115/MSEC2015-9406.

Hölker, R., Haase, M., Ben Khalifa, N., Tekkaya, A. E., 2015. Hot extrusion dies with conformal cooling channels produced by additive manufacturing. In: Materials Today: Proceedings 2, Aluminium 2000 and International Conference on Extrusion and Benchmark (ICEB), Florence, Italy, pp. 4838-4846.

Isik, K., Chen, L., El Budamusi, M., Clausmeyer, T., Becker, C., Tekkaya, A. E., 2015. Enhanced Damage Modelling for Sheet Metal Forming of High Strength Steels - Part 1: Material model, experimental characterization and identification. In: 2nd European Steel Technology and Application Days, Düsseldorf, Germany, (CD).

Isik, K., Doig, M., Richter, H., Clausmeyer, T., Tekkaya, A. E., 2015. Enhancement of Lemaitre Model to Predict Cracks at Low and Negative Triaxialities in Sheet Metal Forming. In: Key Engineering Materials Special Issue SheMet 2015, 639, pp. 427-434.

Levin, E., Haase, M., Foydl, A., Tekkaya, A. E., 2015. Composite extrusion of aluminum with discontinuous eccentric reinforcements. In: Materials Today: Proceedings 2, Aluminium 2000 and International Conference on Extrusion and Benchmark (ICEB), Florence, Italy, pp. 4758-4762.

Lueg-Althoff, J., Gies, S., Weddeling, C., Tekkaya, A. E., 2015. Joining of aluminium tubes by magnetic pulse welding, In: Aluminium - Building the Future, Congress Proceedings, European Aluminium Congress, Session 4, 23.-24.11.2015, Düsseldorf, Germany, pp. 1-15.

May, D., Ortelt, T. R. , Tekkaya, A. E., 2015. Using Remote Laboratories for Transnational Online Learning Environments in Engineering Education. In: Proceedings of E-Learn: World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education 2015, Hawaii, USA, pp. 632-637.

May, D., Sadiki, A., Pleul, C., Tekkaya A. E., 2015. Teaching and learning globally connected – Using live online classes for preparing international engineering students for transnational collaboration and for studying in Germany. In: 12th International Conference on Remote Engineering and Virtual Instrumentation (REV), Bangkok, Thailand, pp. 114-122.

Mennecart, T., Güner, A., Tekkaya, A. E., 2015. Forming behaviour of laser welded Tailor Welded Blanks made out of multi-phase high strength steels - Characterisation, Modelling, and Verification. 2nd European Steel Technology and Application Days, Düsseldorf, Germany, (CD).

Napierala, O., Haase, M., Tekkaya, A. E., 2015. Hollow Lateral Extrusion without Lateral Mandrel. In: JSTP International Seminar on Precision Forging (7th ISPF), Nagoya, Japan, pp. 151-154.

Ossenkemper, S., Haase, M., Tekkaya, A. E., 2015. Composite Cold Forging of Shafts. In: Proceedings of the 48th ICFG Plenary Meeting (ICFG2015) Daejeon, Republic of Korea, pp. 89-94.

Ossenkemper, S., Haase, M., Tekkaya, A. E., Nadolski, D., Schulz, A., Hoffmann, F., Zoch, H., 2015. Cold Forging and Heat Treatment Induced Distorsion. In: Proceedings of the 48th ICFG Plenary Meeting (ICFG2015) Daejeon, Republic of Korea, pp. 14-19.

Sadiki, A., Ortelt, T. R., Pleul, C., Becker, C., Chatti, S., Tekkaya, A. E., 2015. The Challenge of Specimen Handling in Remote Laboratories for Engineering Education. In: 12th International Conference on Remote Engineering and Virtual Instrumentation (REV), Bangkok, Thailand, pp. 187-192.

Schwane, M., Kloppenborg, T., Haase, M., Ben Khalifa, N., Tekkaya, A. E., 2015. Approaches for the Simulation of Composite Extrusion - Possibilities and Limits. In: Materials Today: Proceedings 2, Aluminium 2000 and International Conference on Extrusion and Benchmark (ICEB), Florence, Italy, pp. 4771-4777.

Selvaggio, A., Donati, L., Reggiani, B., Haase, M., Dahnke, C., Schwane, M., Tomesani, L., Tekkaya, A. E., 2015. Effect of Choking and Bearing Length on Metal Flow Balancing in Extrusion Dies. In: Materials Today: Proceedings 2, Aluminium 2000 and International Conference on Extrusion and Benchmark (ICEB), Florence, Italy, pp. 4704-4713.

Staupendahl, D., Becker, C., Tekkaya, A. E., 2015. The Impact of Torsion on the Bending Curve during 3D Bending of Thin-Walled Tubes – a Case Study on Forming Helices. In: Key Engineering Materials 651-653, pp. 1595-1601.

Tekkaya, A. E., Becker, C., Ortelt, T. R., Grzancic, G., 2015. Utilizing Stress Superposition in Metal Forming. In: JSTP International Seminar on Precision Forging (7th ISPF), Nagoya, Japan, pp. 1-6.

Tekkaya, A. E., Hahn, M., Hiegemann, L., Weddeling, C., Ben Khalifa, N., 2015. Umformen faserverstärkter thermoplastischer Kunststoff-Halbzeuge mit metallischen Deckblechen für den Leichtbau. In: 35. EFB-Kolloquium Blechverarbeitung 2015, Intermezzo der hybriden Werkstofflösungen - Hat Blech eine Zukunft?, Bad Boll, Germany, pp. 185-200.

Tekkaya, A. E., Kloppenborg, T., Hölker, R., Schwane, M., Güzel, A., Haase, M., 2015. New Developments in the Simulation of Extrusion Processes. In: Proceedings of the International Conference: New Developments in Forging Technology – NEMU 2015, Stuttgart, Germany, pp. 125-134.

Zeller, S., Beese, S., Gerstein, G., Isik, K., Löhnert, S., Nürnberger, F., Wriggers, P., Maier, H. J., Tekkaya A. E., 2015. Möglichkeiten der simulativen Vorhersage von Temperaturentwicklung und Bauteilversagen infolge plastischer Deformation bei DP600 Bauteilen. In: 18. Workshop Simulation in der Umformtechnik & 3. Industriekolloquium Blechmassivumformung 2015 - DFG Transregio 73, Dortmund, Germany, pp. 113-128.

Vorträge[3] | Presentations[4]

Ben Khalifa, N., 2015. Incremental Profile Forming. 2015 CIRP General Assembly, 23.-29.08.2015, Cape Town, South Africa.

Chen, L., 2015. Experimental characterization and numerical modeling of monolithic and composite sheet in blanking process. Komplastech, 12.01.2015, Krynica-Zdrój, Poland.

Dahnke, C., 2015. Verbundstrangpressen. Werkstoffwoche, Forum 17.03, 14.-17.09.2015, Dresden, Germany.

Dahnke, C., 2015. Exzentrisch positionierte Verstärkungselemente beim partiellen Verbundstrangpressen. WGP Kongress 2015, 07.09.2015, Hamburg, Germany.

Gies, S., 2015. Prozessintegrierter Einsatz der elektromagnetischen Umformtechnologie. Werkstoffwoche, Forum 17.04, 14.-17.09.2015, Dresden, Germany.

Gies, S., Demir, K., Tekkaya, A. E., 2015. Process development for deep drawing with integrated electromagnetic forming. I^2FG / PAK 343 Impulse Forming Workshop 2015, 05.-06.10.2015, Dortmund, Germany.

Isik, K., 2015. Erweiterung des Lemaitre-Modells zur Versagensvorhersage bei niedrigen und negativen Triaxialitäten bei der Blechumformung. Erste Sitzung der Arbeitsgruppe „Simulation“ des DVM, Deutscher Verband für Materialforschung und -prüfung e. V. - Arbeitskreis „Bauteilsicherheit und Bruchmechanik“. 06.10.2015, Kassel, Germany.

Ortelt, T. R., 2015. Teleoperative Prüfzelle als Remote Lab zur Materialcharakterisierung - LIVE-Demo. 44. DGHD Jahrestagung, 03.-06.03.2015, Paderborn, Germany.

Schuster, K., Kuska, R., May, D., Ortelt, T. R., 2015. Ingenieursabusbildung in Zeiten von Digitalisierung und Globalisierung. Fachtagung „Lehr- und Lernformate im Qualitätspakt“, 25.06.2015, Leipzig, Germany.

Selvaggio, A., 2015. Innovative Verfahrensvarianten des Aluminiumstrangpressens. Werkstoffwoche, Forum 17.03, 14.-17.09.2015, Dresden, Germany.

3 Nur der/die Vortragende/die Vortragenden werden genannt.
4 Only the lecturer/the lecturers are stated.

Tekkaya, A. E., 2015. Development of a methodology regarding combined quasi-static and dynamic forming processes. I^2FG / PAK 343 Impulse Forming Workshop 2015, 05.-06.10.2015, Dortmund, Germany.

Forschungsberichte | Research Reports

Tekkaya, A. E., 2015. Integration von Umformen, Trennen und Fügen für die flexible Fertigung von leichten Tragwerkstrukturen. Abschlussbericht: SFB/Transregio 10.

Tekkaya, A. E., Steinbach, F., 2015. Entwicklung von Solarabsorbern in Stahlbauweise auf Basis partiell plattierter Hybridhalbzeuge, Forschungsvereinigung Stahlanwendung e. V. im Stahl-Zentrum, Forschung für die Praxis.

Buchbeiträge | Books

Becker, C., Hermes, M., Tekkaya, A. E., 2015. Incremental Tube Forming. In: Tekkaya, A. E., Homberg, W., Brosius, A., 2015. 60 Excellent Inventions in Metal Forming. Springer Vieweg, Berlin, pp. 351-356.

Dahnke, C., Kloppenborg, T., Schwane, M., Schikorra, M., Pietzka, D., Kleiner, M., Schomäcker, M., 2015. Composite Extrusion. In: Tekkaya, A. E., Homberg, W., Brosius, A., 2015. 60 Excellent Inventions in Metal Forming. Springer Vieweg, Berlin, pp. 275-280.

Haase, M., Ben Khalifa, N., 2015. Chip Extrusion with Integrated Equal Channel Angular Pressing. In: Tekkaya, A. E., Homberg, W., Brosius, A., 2015. 60 Excellent Inventions in Metal Forming. Springer Vieweg, Berlin, pp. 261-266.

Hermes, M., Staupendahl, D., Kleiner, M., 2015. Torque Superposed Spatial bending. In: Tekkaya, A. E., Homberg, W., Brosius, A., 2015. 60 Excellent Inventions in Metal Forming. Springer Vieweg, Berlin, pp. 381-386.

Grzancic, G., Becker, C., Hermes, M.,2015. Incremental Profile Forming. In: Tekkaya, A. E., Homberg, W., Brosius, A., 2015. 60 Excellent Inventions in Metal Forming. Springer Vieweg, Berlin, pp. 357-362.

Güner, A., Tekkaya, A. E., 2015. In-Situ Measurement of Loading Stresses by Means of X-ray Diffraction with Multi-State Sheet Specimen. In: Tekkaya, A. E., Homberg, W., Brosius, A., 2015. 60 Excellent Inventions in Metal Forming. Springer Vieweg, Berlin, pp. 397-402.

Kwiatkowski, L., Tekkaya, A. E., 2015. TwinTool. In: Tekkaya, A. E., Homberg, W., Brosius, A., 2015. 60 Excellent Inventions in Metal Forming. Springer Vieweg, Berlin, pp. 161-166.

Mennecart, T., Kolbe, J., Kleiner, M., 2015. Hybrid Deep Drawing Tools for High Strength Steels. In: Tekkaya, A. E., Homberg, W., Brosius, A., 2015. 60 Excellent Inventions in Metal Forming. Springer Vieweg, Berlin, pp. 83-88.

Selvaggio, A., Becker, D., Klaus, A., Arendes, D., Kleiner, M., 2015. Curved Profile Extrusion. In: Tekkaya, A. E., Homberg, W., Brosius, A., 2015. 60 Excellent Inventions in Metal Forming. Springer Vieweg, Berlin, pp. 287-292.

Traphöner, H., Qing, Y., Tekkaya, E. A., 2015. Sheet Material Characterization with the In-Plane Torsion Test: Cyclic Loading, Grooved Specimen and Twin Bridge Specimen. In: Tekkaya, A. E., Homberg, W., Brosius, A., 2015. 60 Excellent Inventions in Metal Forming. Springer Vieweg, Berlin, pp. 17-22.

Herausgeberschaft | Editorship

Tekkaya, A. E., Homberg, W., Brosius, A., 2015. 60 Excellent Inventions in Metal Forming. Springer Vieweg, Berlin.

Technische Magazine | Technical Magazines

Groche, P., Stein, P., Überlacker, D., Neumayer, F., Steinbach, F., 2015. Trockenscherschneiden von Verbundblechen. Einflussgrößen auf die Schnittgeometrie. Werkstattstechnik 105 (10), pp. 733-737.

Napierala, O., Haase, M., Tekkaya, A. E., Wälder, J., Felde, A., Liewald, M., 2015. Analyse und Optimierung des Hohl-Quer-Fließpressens ohne Querdorne. International Aluminium Journal 6, pp. 75-79.

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