
IUL

Institute of
Forming Technology and
Lightweight Construction

Activity Report

11

technische universität
dortmund

Imprint

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Inhalt

Preface

Dear reader,

The natural catastrophe on the northeastern coast of Japan on the 11th of March 2011 killed over 15,800 people. 3,300 victims are still missing. 6,000 were, in part, seriously injured. This was the result of the melting of nuclear reactor cores in Fukushima. We would like to express here once more our deepest sympathy to our Japanese colleagues. We welcomed our Japanese colleagues with great respect to the 10th ICTP in September to Aachen, listened to their accounts of the terrifying events and were impressed by the Japanese People´s level-headed attitude, discipline and social awareness.
This tragedy also had radical consequences for the energy policy in Germany. The issue of energy efficiency was given increased priority. Electric mobility is now even more a clear objective of the industry and, in this way, lightweight construction as well is further emphasized in research and development work. This had an immediate influence on our research activities already in the second half of the year and it will set clear priorities for the years to come.
There were two more events in 2011 that have concerned us: As an internationally acting institute, both internally and externally, we were alerted by the reports on the discovery of extreme right-wing crimes and then reassured by the resolute reaction of the society. And the plagiarism scandals have again put into focus scientific and academic ethics as an indispensable basic condition for our activities.

We are very glad about the further growth of our institute. Through the major project "ELLI" funded by the German Federal Ministry of Education and Research (BMBF), we will be able to further develop research for education in co-operation with our colleagues from Aachen and Bochum. In addition to this, the project "The Laboratory within Engineering Education" will provide us with important findings allowing us to improve practical teaching activities. Here and in other projects, the close co-operation with institutions of higher education didactics is indispensable. At the end of the year, this fruitful co-operation resulted in the foundation of the informal "research association engineering didactics", which will be institutionalized next year.

The institute has extended its research activities by the newly founded department of "Applied Mechanics in Forming Technologies". This department will be the coupling link in the now even closer co-operation with our colleagues from the Institute of Mechanics and, in this way, promote our fundamental research work in forming technology by applying established methods and approaches from mechanics in processes of forming technology. The German French Summer School on the subject "damage in metal forming" will already be an important activity of this new department in 2012.

A large number of prominent international guests visited the IUL in 2011. These scientists did not only give lectures and presentations but took actively part in the scientific research work. We would like to express here again our great appreciation to all our guests for this outstanding co-operation. In 2012 we will also welcome numerous international guests to our institute and, in this way, initiate fruitful co-operations.

The international study program „Master of Manufacturing Technology" (MMT) was successfully launched in October 2011. As the first cohort, 13 highly skilled students out of 75 applicants were admitted to take up their studies. The students come from China, Columbia, India, Iran, Japan and Turkey. Already in this first semester, students as well as teachers are very content. The program is significantly supported by the rectorate, for which we, and also in the name of the university teachers of the Faculty of Mechanical Engineering, would like to express our gratefulness.

The 10th International Conference on Technology of Plasticity (ICTP) was another highlight in 2011. It was organized in co-operation with our dear colleague Gerhard Hirt from the Institute of Metal Forming (IBF) of RWTH Aachen on behalf of the German Metal Forming Association (AGU) in Aachen. This conference, which is often referred to as the "Olympic Games in Forming Technology", broke a record this year by hosting over 700 participants. Furthermore, in the frame of this

conference, the International Karl-Kolle Prize in recognition of innovative achievements in metal forming was awarded by AGU for the first time.

IUL´s alumni were invited this year to meet the present staff members of the institute in the experimental hall for an intense exchange of ideas. Due to the very positive feedback, we would like to continue this exchange of ideas in the frame of such a meeting, which is also a social gathering, in the years to come.

Finally, we would like to cordially thank all IUL staff members for their outstanding commitment. In the same way, we would like to thank the institutions who support our research activities, the numerous industrial partners as well as all colleagues with whom we maintain fruitful co-operations.

Matthias Kleiner

A. Erman Tekkaya

Alexander Brosius

1 Education

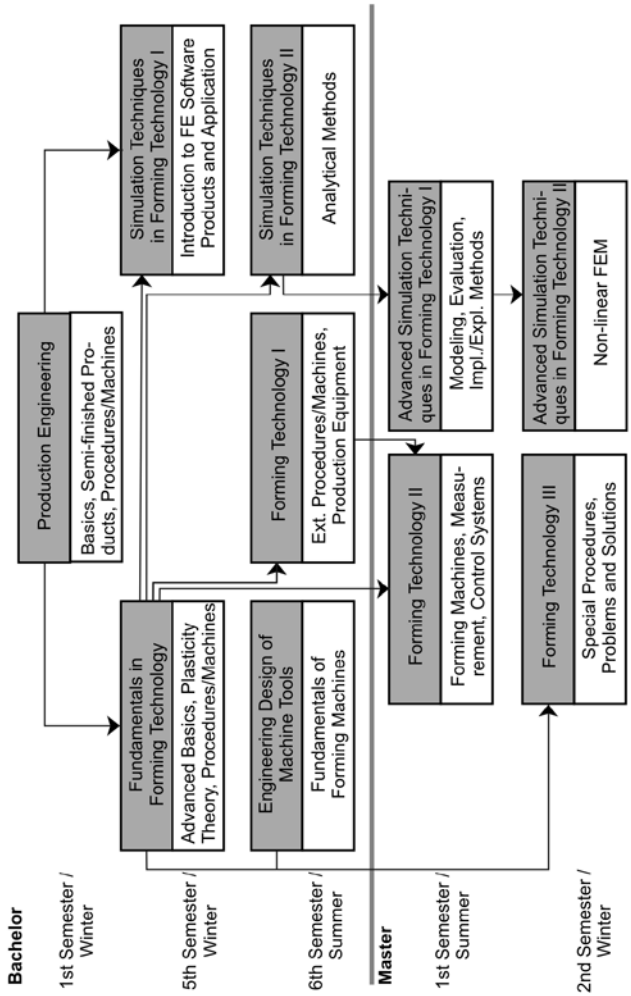
1.1 Lectures

The new bachelor courses Mechanical Engineering, Industrial Engineering and Management, and Logistics have started successfully in winter semester 2008. The IUL lecture structure was adapted to these programs (see figure on page 2). The master courses started in summer semester 2010.

The lecture "Production Engineering" is provided in cooperation with the Institute of Machining Technology (ISF) and scheduled for all courses of studies stated above. The part of the IUL imparts basic knowledge in bulk metal technology with main focus on manufacturing of semi-finished products and important procedures in massive forming and sheet metal forming. The subsequent lectures "Fundamentals in Forming Technology" and „Forming Technology I and III" deepen this technological basic knowledge with a detailed presentation of advanced theoretical basics, relevant forming procedures, and necessary process chains.

Knowledge about forming machines and the corresponding competences with respect to instrumentation, control, and automation is presented in the lectures „Engineering Design of Machine Tools" and "Forming Technology II". Furthermore, the compulsory modules "Virtual Production Techniques I-II" and "Advanced Simulation Techniques I-II" offer the necessary basics on numerical simulation of forming processes.

Restructured lectures illustrated by the example of mechanical engineering, focus on production engineering



1.2 Offered Courses – Content

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.

Production Engineering – Subject "Forming Production"

Prof. Dr.-Ing. A. E. Tekkaya • Dr.-Ing. habil. S. Chatti
Dipl.-Ing. Th. Mennecart

In cooperation with the Institute of Machining Technology

Scope 2 L
Date winter semester

Content IUL

The lecture „Production Engineering" gives students an overview of the processes and machines used in production technology. The lecture is held in cooperation with the Institute of Machining Technology (ISF). The ISF starts with an introduction to machining technology and the IUL subsequently schedules a presentation of primary shaping and forming within six sessions.

- Product examples, forming production, process overview
- Relevant basics
- Overview of primary shaping processes
- Bulk forming processes: rolling, compression/forging, and extrusion

- Sheet metal forming processes: die bending/swivel bending, stretch drawing, and deep drawing
- Lightweight construction and outlook on advanced lectures in forming

Fundamentals in Forming Technology

Prof. Dr.-Ing. A. E. Tekkaya • Dr.-Ing. habil. S. Chatti • Dipl.-Ing. Q. Yin
Dipl.-Ing. S. Gies • Dipl.-Ing. S. Ossenkemper

Scope 2 L + 1 T
Date winter semester

The lecture „Fundamentals in Forming Technology“ gives a detailed introduction to forming technology and extensively discusses the theoretical basics.

- Metallurgical fundamentals in forming technology
- Flow curve, theory of plasticity, and friction model
- Strip, disc, and tube model
- Material characterization
- Membrane theory
- Analytical methods, computing methods (load bounding method)
- Forming limit curves (FLC)
- Bulk forming processes (rolling, profile rolling, compression, forging, extrusion, wire drawing)
- Sheet metal forming processes (die bending, swivel bending, stretch drawing, deep drawing)
- Cutting and joining
- Overview of forming machines
- Laboratory lecture with guided tour illustrating the individual forming processes

Forming Technology I/Forming Technology in Industrial Engineering and Management I

Prof. Dr.-Ing. A. E. Tekkaya • Dr.-Ing. habil. S. Chatti

Scope 2 L + 1 T
Date summer semester

The lecture „Forming Technology I" is based on the lecture „Fundamentals in Forming Technology". Important forming processes, process chains as well as tools and materials which have not yet been discussed are explained in detail.

- Materials in forming technology
- Extrusion I – Basics and standard methods
- Extrusion II – Process chain, failure, and economic efficiency
- Manufacturing of profiles by roll forming
- Reducing, ironing, and drawing
- Metal spinning processes
- Profile bending and tube bending
- High pressure forming
- Working media-based sheet metal forming
- Materials in forming technology
- Seminar lectures

Aspects concerning all forming processes

- Process principle and variations
- Analytical modeling (state of stress, state of strain)
- Force path during the forming process
- Failure examples
- Technological information (machinery, tools)

Engineering Design of Machine Tools

Prof. Dr.-Ing. A. E. Tekkaya • Dr.-Ing. M. Trompeter • M.Sc. V. Franzen
Dipl.-Ing. B. Plugge

In cooperation with the Institute of Machining Technology (ISF)

Scope 2 L + 2 T
Date summer semester

Content IUL

The lecture „Engineering Design of Machine Tools“ introduces the relevant fundamentals with regard to the design of production engineering machine tools. The lecture is held in cooperation with the Institute of Machining Technology and is structured as follows:

- Introduction
- Frames/guidings
- Gears/engines
- Control and sensors
- Work-linked presses
- Stroke-linked presses
- Force-linked presses
- Press design
- Bending and rolling machines
- Servo presses and special purpose machines

Simulation Methods in Forming Technology I/ Methods of Virtual Production II

Prof. Dr.-Ing. A. E. Tekkaya • Dr.-Ing. habil. S. Chatti
Dipl.-Ing. F. Steinbach

Scope 2 L + 1 T
Date winter semester

The lecture „Simulation Methods in Forming Technology I/ Methods of Virtual Production II" provides a detailed introduction to FEM which is illustrated by various examples from the field of forming technology. Apart from different means of time integration and essential element types students become acquainted with diverse simulation software tools within the scope of the lecture as well as the tutorial. Furthermore, different means of optimization by using FEM simulations are being discussed.

- Introduction
- Introduction to fundamentals of FEM
- Solution methodology by means of examples
- Introduction to ABAQUS
- Modeling and simulation with ABAQUS
- Introduction to LS-DYNA
- Modeling and simulation with LS-DYNA
- Introduction to other FE programs
- Examples from practice
- Seminar presentations

Simulation Methods in Forming Technology II/ Methods of Virtual Production I

Prof. Dr.-Ing. A. E. Tekkaya • Jun.-Prof. Dr.-Ing. A. Brosius
Dipl.-Ing. J. Witulski • M.Sc. A. Güzel • M.Sc. A. Güner

Scope 2 L + 1 T
Date summer semester

The lecture “Simulation Methods in Forming Technology II/ Methods of Virtual Production I” presents forming technology methods used for modeling of forming operations.

- Application examples (process simulation, component layout etc.)
- State of deformation & state of stress (basics, special cases, von Mises criterion/Tresca criterion, introduction to anisotropy)
- Flow criteria, flow curve, flow rule, parameter identification
- Specification of analytical, semi-analytical, and numerical approaches
- Slip-line theory, upper-bound method, and membrane theory
- Thermodynamics in forming technology
- Introduction to tribology
- Introduction to the Finite Element Method (FEM) and Finite Volume Method (FVM) including interpretation and application

Advanced Simulation Methods in Forming Technology II/ Virtual Forming Technology I

Prof. Dr.-Ing. A. E. Tekkaya • Jun.-Prof. Dr.-Ing. A. Brosius

Scope 2 L + 1 T
Date summer semester

The lecture provides students with deep basics of non-linear FEM. For this reason, the various types of material, structural, and contact nonlinearities are discussed. The approaches should take into account specific aspects of the use of FEM in metal forming. In the field of sheet metal forming implicit and explicit solution procedures are in the foreground, in the area of bulk forming, Euler, Lagrange and ALE formulation, and, in the field of hot forming, thermo-mechanical coupling.

After successful participation, the students are able to create a model for a metal forming process, to perform calculations with the implemented model, and finally to evaluate the computation results. The following topics are covered in this lecture:

- Review of linear FEM
- Introduction to non-linear FEM
- Geometric non-linearity
- Material non-linearity
- Contact problems
- Solving non-linear equation systems

Virtual Forming Technology II

Prof. Dr.-Ing. A. E. Tekkaya • Jun.-Prof. Dr.-Ing. A. Brosius
M.Sc. A. Güner

Scope 2 L + 1 T
Date winter semester

This lecture builds on the lecture Virtual Forming Technology I and introduces additional content such as rigid plastic, elastic-plastic and viscoplastic FEM. In addition, the advanced basics are applied in the form of case studies to metal forming problems. Furthermore, through homework and small-group seminars, the student's team skills are trained and the presentation techniques are improved.

- Rigid plastic FEM
- Elastic-plastic FEM
- Viscoplastic FEM
- Particular aspects of FEM

Forming Technology II

Prof. Dr.-Ing. A. E. Tekkaya • Dipl.-Ing. M. Hermes
M.Sc. M.Eng. Ch. Pleul • Dipl.-Ing. Ch. Becker

Scope 2 L + 1 T
Date summer semester

The lecture „Forming Technology II“ provides an in-depth overview of forming machines and tools through laboratory project and seminar work. In the problem-based laboratory project a real forming problem involving a metal forming machine or process is the central starting point in the overall context of forming technology. By specifying and dealing with these problems students deepen and professionalize the application of engineering approaches, such as design systematics, problem solving techniques, experimentation/validation, and project planning and control. In addition, scientific methods for gathering information as well as true and objective presentation of subjects and results are applied.

Students gather the necessary basics and then knowledge about special problems of metal forming. The acquired theoretical and practical knowledge is applied creatively to develop innovative solutions. The structure of the course supports the scientific-analytical approach for solving engineering problems in metal forming. Through the design as a laboratory project the ability for experimental work is improved in the application-oriented scientific context.

Forming Technology III/Forming Technology in Industrial Engineering and Management II

Prof. Dr.-Ing. A. E. Tekkaya • Dr.-Ing. habil. S. Chatti
Dipl.-Ing. L.Kwiatkowski

Scope 2 L + 1 T/field trip
Date winter semester

The lecture "Forming Technology III" deals with special procedures of forming technology. Students acquire knowledge about non-conventional forming procedures, procedures extensions, procedures particularities, problems and problem handling. Furthermore, already existing knowledge is intensified. On the basis of seminars and project work, the theoretical knowledge is complemented with practical examples. The results are presented in the final presentations.

- Superplastic forming
- High-speed forming processes
- Incremental forming
- Thixoforiming
- Special extrusion procedures
- Special procedures of bending
- Micro forming procedures
- Hot sheet metal forming
- Seminar presentations

MMT I – Forming Technology – Bulk Forming

Prof. Dr.-Ing. A. E. Tekkaya • Dr.-Ing. habil. S. Chatti

Scope 2.5 L + 1 T
Date winter semester

This lecture was offered for first time in the scope of the international Master of Science in Manufacturing Technology (MMT). It is held in English language and provides an advanced knowledge of the fundamentals of forming manufacturing technology and the corresponding forming machines and processes. In addition, theoretical fundamentals with a special emphasis on the finite element method are discussed.

With the successful participation in this module, students gain a broad understanding of the processes of metal forming and related machinery and tools. The students are able to identify special problems of metal forming technology, treat them and offer solutions. They possess a broad understanding of components, measurement and control systems, and automation techniques. The lecture, the accompanying seminars, project work and exercises extend students' analytical thinking, communication and team-work skills.

The lecture contents are divided into three main parts: basics, applications and machines/energy.

- Materials in forming technology
- Theory of plasticity
- Material characterization
- Analytical methods
- Rolling
- Forging
- Cold forging
- Bar extrusion
- Reducing and drawing
- Shear forming and flow forming
- Forming machines
- Energy and resource efficient manufacturing

Industrial Lecture Course: Industrial Field Reports

Prof. Dr.-Ing. A. E. Tekkaya et al.

Scope 2 L
Date winter semester, summer semester

Invited guest speakers from industry provide first-hand insight into practical applications. To ensure a broad professional exchange this lecture course addresses students of different majors as well as university research and industrial staff. The course covers the subjects of sheet metal forming and bulk forming.

Specialist Laboratory A for Students of Mechanical Engineering

Within the scope of the specialist laboratory the students of mechanical engineering carry out one of the following tests, depending on winter or summer semester

- Hydraulic deep drawing test and tensile test
- Material characterization by a tensile and compression test

After teaching the theoretical aspects and testing the knowledge of the students, experimental tests are carried out and the required data is acquired. Afterwards, the tests are simulated in order to e.g. find out the friction coefficient in compression tests. The evaluation of the results is carried out by means of a scientific report which has to be prepared by student groups of up to four students.

Specialist Labratory B for Students of Industrial Engineering

Within the scope of this specialist laboratory the students carry out a uniaxial flat tensile test on the universal testing machine ZWICK Z250 in the winter semester. The material specific data is recorded during the test and evaluated regarding its suitability for forming processes. The tests and the results achieved are then summarized in a scientific laboratory report.

Seminars

Seminar topics of the lecture „Forming Technology I/Forming Technology in Industrial Engineering and Management I“:

- Metrology for materials characterization
- Metrology in industrial extrusion processes
- Metrology in extrusion dies
- Metrology for bending tubes and profiles
- Metrology in hydroforming
- Metrology in working media based sheet metal forming

Seminar topics of the lecture “Forming Technology III/Forming Technology in Industrial Engineering and Management II”:

- Surface features of extruded profiles
- Mechanisms of the explosive welding
- Calculation of the press forces in extrusion
- Creation of a product range for incremental sheet metal forming
- Metrology for electromagnetic forming
- Stress superposition in sheet metal forming

Seminar topics of the lecture “Simulation Methods in Forming Technology I/ Methods of Virtual Production II”:

- History of FEM
- Material models and anisotropy
- Flow curves
- Forming limit curve (FLC)
- Friction models
- Finite volume method

Tutorials

Financed from study fees, the following tutorials have been offered by the IUL in 2011:

- CAD with Catia-V5 for beginners
- CAD with Catia-V5 for advanced learners
- Introduction to the simulation of bulk forming with Deform
- Simulation with Deform for advanced learners
- Introduction to the simulation software LSDyna
- Introduction to the measurement technology with GOM systems
- Scientific work with LaTeX for beginners
- Photoshop/Graphic design basics

1.3 Successful Start of the International Study Program Master of Science in Manufacturing Technology (MMT)

Start of program	October 2011
Coordination	Prof. Dr.-Ing. A. E. Tekkaya M.Sc. M.Eng. Ch. Pleul Dipl.-Ing. D. Staupendahl Dipl.-Fachübers. A. Hallen

„We need excellent minds to counter the competition from China, Japan, and India. We need the best people as scientists, but these people do not come to Germany." Prof. Dr.-Ing. A. E. Tekkaya is amazed about how little effort German universities put into attracting students from foreign countries and – has done pioneer work. Finally and with great dedication and enthusiasm, 13 selected international students enrolled in the new master program „Master of Science in Manufacturing Technology (MMT)" at TU Dortmund University in this winter semester 2011/2012. The MMT is an English-language four-semester master program focusing on production engineering. It is research-oriented and at the same time consistently practice-led through close co-operation with renowned industrial companies. The master program is tailored to dedicated and highly motivated students and graduates of renowned German and foreign universities with main emphasis on international students. Scholarships are granted to selected students. Highly qualified scientific research assistants of the chairs and institutes involved in the program provide assistance and guidance to all MMT students as mentors.

The MMT program was drawn up by the IUL in co-operation with the Institute of Machining Technology, the Institute of Mechanics, the Institute of Materials Engineering, the Chair of Industrial Engineering, the Chair of Industrial Robotics and Production Automation, and the Chair of Measurement and Test Engineering (today: Department of Materials Test Engineering). The MMT program was accredited by the accreditation agency ASIIN on the 1st of October 2010 and reaccredited on the 30th of September 2011. In this course, the EUR-ACE® label, too, was awarded i.e. the approval for Europe.

Program contents and profile

Mechanical engineers are significant pioneers for progress and development in the field of industrial production. Germany as a location for business is characterized by excellent industrial production and scientific research at international level. Due to the increasing complexity of mechanical engineering developments a comprehensive understanding of the coherences within and between the individual fields of mechanical engineering is essential. Owing to an increasing globalization in the production sector cross-cultural communication has become a decisive criterion for success. English being the language of instruction, students become prepared for the integration in international networks. The master program „Master of Science in Manufacturing Technology“ equips students with detailed knowledge, skills, and competences in the field of interdisciplinary production engineering. Researching learning represents a key component in this context. For this purpose, students are offered lectures and courses at different chairs and institutes of the Faculty of Mechanical Engineering. Thanks to the program‘s language being English and its international structure as well as due to the close cooperation with renowned industrial companies, students are prepared in the best possible way for a professional career in the production sector.

„Welcome Brunch“ at the experimental hall

Program structure

During the first two semesters students gain profound knowledge and skills in machining technology, materials science, and forming technology. In addition, students choose three elective modules according to their personal interests. The third semester is characterized by project and laboratory work, teaching students the competence of applying theoretical knowledge in practical applications. The module "Interdisciplinary qualification" is geared to impart soft skills as well as language skills in order to prepare students for their later profession. The master's thesis is scheduled for the fourth semester.

	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

Overview of the MMT master's program curriculum

Students shape their individual profiles by choosing three out of seven of the following elective modules:

- Automation and Robotics
- Simulation Methods in Solid Mechanics
- Work System and Process Design
- Modern Machine Tool Design
- Advanced Simulation Techniques in Metal Forming
- Measurement Engineering
- Fatigue Behavior

Learning and researching in international teams

Extensive laboratory work comprises practical investigations on chosen production engineering contents, leading students to solve problems independently. The laboratory work being organized as group work encourages the students' ability to work in a team.

Scientific project work which shall be carried out in close co-operation with leading industrial enterprises includes a seminar paper to be prepared as group work. Students are qualified for a critical classification of scientific findings and are enabled to apply theoretical knowledge. By working in an intercultural team and finally presenting the results the students' social and presentation skills are trained.

Graduates' career outlook

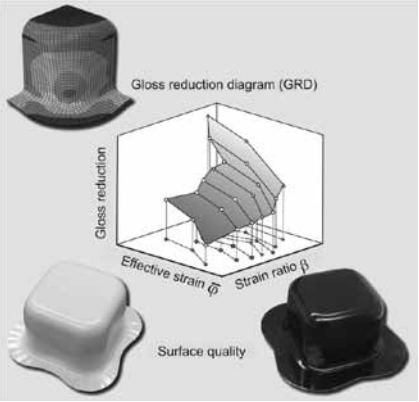
Professional prospects for graduates are excellent. The demand for engineers is high. Graduates in the field of production engineering have outstanding earning and employment prospects and they will find interesting challenges. They can choose from a wide range of professional activities, from the development of new processing techniques to the planning of complex production lines. Furthermore, graduates with the degree "Master of Science in Manufacturing Technology" are qualified for a doctorate.

Looking expectantly towards the future: Professor Tekkaya and his team with the MMT students at the IUL

1.4 Doctoral Theses

Pham, Ha-Duong	Process Design for the Forming of Organically Coated Sheet Metal
Original title	Prozessauslegung zur Umformung von organisch beschichteten Blechen
Series	Dortmunder Umformtechnik
Publisher	Shaker Verlag, Aachen, 2011
Oral exam	May 31, 2011
Advisor	Prof. Dr.-Ing. A. E. Tekkaya
Co-Advisor	Prof. Dr.-Ing. W. Homberg

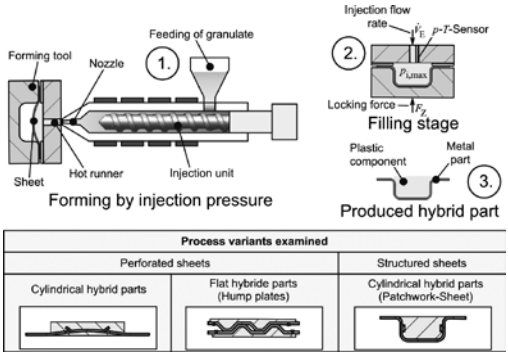
In this research work, the process design for forming of organically coated sheet metal (OCSM) is investigated. The research aims to investigate the forming behavior focusing on changes of the optical properties i.e. gloss degree and the prediction of the change of the surface properties.
The obtained results indicate that the gloss reduction of the coated surface is caused by the strain states and strain level imposed on both steel substrate and the coating layer. In order to predict exactly the coating failures, the forming limit diagram of coating (FLDC) should be used instead of the forming limit diagram (FLD) of steel substrate.
The influences of process parameters on the surface property of OCSM products in hydro-mechanical deep drawing (HDD) are also investigated. For this purpose, an analytical model is developed. Based on the obtained results, the HDD process can be optimized with regard to the best surface characteristics of organically coated layers.



Process design for the forming of organically coated sheet metals

Rauscher, Boris	Positive-Locking Metal-Plastic Hybrid Components by Integration of Sheet Metal Forming and Injection Molding
Original title	Formschlüssig verbundene Metall-Kunststoff-Hybridbauteile durch Integration von Blechumformung und Spritzgießen
Series	Dortmunder Umformtechnik
Publisher	Shaker Verlag, Aachen
Oral exam	June 6, 2011
Advisor	Prof. Dr.-Ing. A. E. Tekkaya
Co-Advisor	Prof. Dr.-Ing. B.-A. Behrens Jun.-Prof. Dr.-Ing. A. Brosius

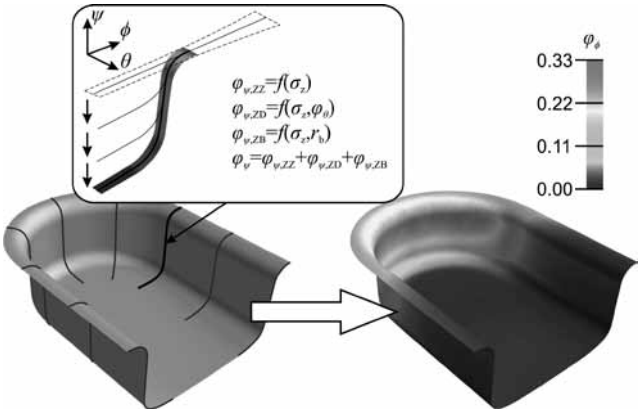
This thesis presents a fundamental investigation on the manufacturing of positive-locking metal-plastic hybrid components by polymer injection forming (PIF). PIF is a process which beneficially integrates working media based sheet metal forming and injection moulding in order to produce light metal-plastic parts featuring a high degree of functions. The polymer which is used as pressure medium in the molten state to form geometrical features in the sheet metal remains as a functional part in the final hybrid structure. In this thesis the PIF process is applied using semi-finished metal sheets which can be adapted in regard to the requirement specifications of the hybrid part. The focus is set on the application of semi-finished sheets featuring cuttings and patchwork elements in order to ensure high-strength positive-locking joints. For each type of hybrid part, cylindrical as well as flat geometries, process limits have been identified applying experimental and numerical methods.



Process principle of an integrated manufacturing process of forming and injection molding and process variants examined

Cwiekala, Tim	Development of a Simulation Method for a Time-Efficient Calculation of Deep Drawing Processes
Original title	Entwicklung einer Simulationsmethode zur zeiteffizienten Berechnung von Tiefziehprozessen
Series	Dortmunder Umformtechnik
Publisher	Shaker Verlag, Aachen
Oral exam	November 18, 2011
Advisor	Jun.-Prof. Dr.-Ing. A. Brosius
Co-Advisor	Prof. Dr.-Ing. W. Volk Prof. Dr.-Ing. A. E. Tekkaya

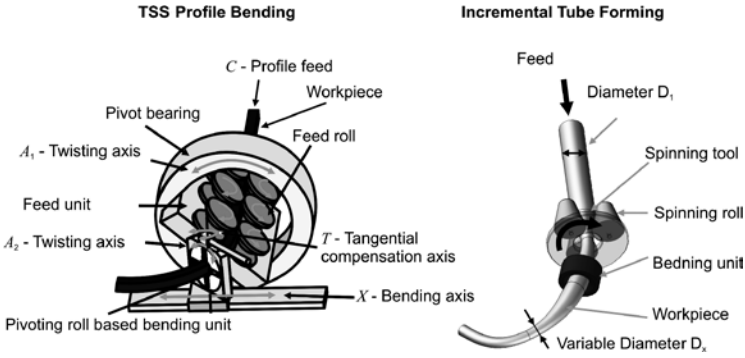
Finite element simulations of deep drawing processes are very time-consuming due to non-linearities. Especially more complex tasks, as e.g. optimization processes, require a multiple of this calculation time. Faster simulation methods are not sufficient as important influencing factors would be neglected.
In this work a simulation method for deep drawing processes is developed, which allows a short computation time and considers all relevant influencing factors in such a way that the strain distributions in the part can be predicted with high accuracy. This method was developed by combining and improving different analytical approaches, to allow the prediction of strains along section lines of 3D deep drawing parts and thus the prediction of formability. Due to its analytical character the developed method allows the calculation of deep drawing processes within one second.



Simulation method for deep drawing processes

Hermes, Matthias	New Processes for Roll based 3D Bending of Profiles
Original title	Neue Verfahren zum rollenbasierten 3D-Biegen von Profilen
Series	Dortmunder Umformtechnik
Publisher	Shaker Verlag, Aachen
Oral exam	December 6, 2011
Advisor	Prof. Dr.-Ing. M. Kleiner
Co-Advisor	Prof. Dr.-Ing. A. E. Tekkaya Prof. Dr.-Ing. P. Groche

Due to the increasing demand of complex 3D bent parts made of tubes and profiles with arbitrary cross sections, different bending processes were developed within this work.
The method of engineering design was used to generate new bending process variants for spatial profile parts. The first result was the Incremental Tube Forming process (ITF), which is a combination of spinning and freeform tube bending that allows the production of bent tubes with a variation of diameter over the longitudinal axis at the same time. The second generated process was the TSS (Torque Superposed Spatial) bending process, which is a roll based 3D bending method for profiles with arbitrary cross sections.
The TSS bending process was further developed in this work. First of all a prototype machine concept was designed and built. Second based on an analytical model a special process planning system to solve applied bending problems was developed.



Process Concepts ITF and TSS

1.5 Completed Master Theses

Hristov, Ivan Vasilev
Supervisor: Remmel, J. (TFH Bochum) • Tekkaya, A. E.
Pietzka, D.
Original title: Entwicklung und Konstruktion einer flexiblen Online-Führung und eines Auslaufs für Strangpressprofile
Development and design of a flexible guide and puller for extrusion profiles

Rahman, Aulia
Supervisor: Tekkaya, A. E. • Sebastiani, G.
Statistically designed experimental investigation of the thickness effects on the quality of incrementally formed parts

Saibola, Vijay Prabhakar
Supervisor: Tekkaya, A. E. • Franzen, V.
Multistage ISF approach for producing deep drawing tools

1.6 Completed Diploma Theses

Funk, Jan
Supervisor: Tekkaya, A. E. • Hölker, R.
Original title: Herstellung von Werkzeugen für die Warmmassivumformung mittels Verfahren des Rapid Tooling
Manufacturing of dies for hot metal forming by using rapid tooling technologies

Gies, Soeren
Supervisor: Brosius, A. • Weddeling, Ch.
Original title: Analytische und experimentelle Untersuchungen zur Fügestellengestaltung bei der elektromagnetischen Kompression unter besonderer Berücksichtigung gerändelter Formschlusselemente
Analytical and experimental investigations on the design of knurled connections for joining by electromagnetic forming

Hoos, Michael
Supervisor: Tekkaya, A. E. • Sebastiani, G.
Original title: Entwicklung und Konstruktion eines flexiblen Gegenwerkzeugs für die asymmetrische inkrementelle Blechumformung
Design of a flexible support tool for AISF

Matusin, Dejan
Supervisor: Tekkaya, A. E. • Becker, Ch.
Original title: Untersuchung von Prozessparametern beim Inkrementellen Rohrumformen
Examination of process parameters of Incremental Tube Forming

Sahraoui, Omar
Supervisor: Zwiers, U. (FH Bochum) • Brosius, A.
M. Gharbi, M.
Original title: Untersuchung des Versagens beim Blechbiegen mit überlagerter Spannung mittels FEM
Finite Element Analysis of Damage in Sheet Metal Bending Process with Stress Superposition

Savvidis, Themistoklis
Supervisor: Tekkaya, A. E. • Pleul, Ch.
Original title: Automatisierung des Spannprozesses einer Universalprüfmaschine
Automation of the clamping procedure for tele-operated material characterization

Schuster, Philipp
Supervisor: Tekkaya, A. E. • Chatti, S.
Original title: Experimentelle Untersuchung zum Einfluss geometrischer und prozesstechnischer Parameter auf die Ausbildung der Schnittflächenmerkmale Kanteneinfall und Lochgrat beim Lochen gegen Innendruck im Hydroform-Werkzeug
Experimental investigation on the influence of geometrical and process parameters on the formation of the cutting surface features edge inclination and hole burr during punching against internal high pressure in the hydroforming tool

Turan, Emrah
Supervisor: Tekkaya, A. E. • Foydl, A.
Original title: Experimentelle Untersuchung zum Einbringen von diskontinuierlichen Verstärkungselementen mit unterschiedlichen Geometrien beim Verbundstrangpressen
Experimental investigation on discontinuous reinforcing elements with differing geometries in composite extrusion

Wawrosch, Arthur
Supervisor: Brosius, A. • Sebastiani, G.
Original title: Analyse und Evaluation eines flexiblen Gegenwerkzeugkonzeptes bei der asymmetrischen inkrementellen Blechumformung
Analysis and evaluation of flexible support tools in AISF

Zeyd Kaya , Aydogan
Supervisor: Heinrichs, H. (FH Aachen) • Tekkaya, A. E. Staupendahl, D. • Hermes, M.
Original title: Konstruktive Erweiterung der TSS-Profilbiegemaschine um zwei zusätzliche CNC-Servoachsen
Extension of the TSS profile bending process by two additional CNC servo axes

1.7 Completed Bachelor Theses

Backs, Dominik
Supervisor: Tekkaya, A. E. • Pietzka, D.
Original title: Experimentelle und numerische Untersuchungen zum Einfluss der Verstärkungselemente auf das Fertigungsverfahren Verbundstrangpressen
Experimental and numerical investigations of the influence of reinforcing elements on the composite extrusion process

Bröckerhoff, Stephan
Supervisor: Albien, E. (FH Dortmund) • Tekkaya, A. E.
Hänisch, S.
Original title: Konzeption eines modularen Werkzeugs zum Tiefzieh-Späne-Verbundfließpressen
Conception of a modular tool for combined deep drawing and cold forging with chips

Geese, Jan Stephan
Supervisor: Brosius, A. • M. Gharbi, M. • Becker, Ch.
Original title: Konstruktion und Fertigung eines Prototyps von Schienenbefestigungselementen
Design and production of a prototype for rail fasteners

Hahn, Marlon
Supervisor: Brosius, A. • Weddeling, Ch.
Original title: Machbarkeitsstudie zum Magnetimpulsschweißen von Blech-Blech-Verbindungen mittels „Uniform Pressure Electromagnetic Actuator"
Feasibility study on magnetic pulse welding of sheet-to-sheet connections using the "Uniform Pressure Electromagnetic Actuator"

Hassouni, Hamid
Supervisor: Abel, H.-J. (FH Dortmund) • Brosius, A.
M. Gharbi, M. • Becker, Ch.
Original title: Numerische Simulation eines Versuchstandes zur Beschreibung inkrementeller Fertigungsprozesse
Numerical Simulation of a Testing Setup to Describe Incremental Forming Processes

Löbbe, Christian
Supervisor: Tekkaya, A. E. • Staupendahl, D. • Hermes, M.
Original title: Verfahrenserweiterung des TSS-Profilbiegeprozesses mittels induktiver Wirbelstromerwärmung für ferromagnetische Rundrohre
Process extension of the TSS profile bending process by induction heating of ferromagnetic tubes

1.8 Completed Student Theses

Bay, Hakan • El Budamusi, Mohamed
Supervisor: Tekkaya, A. E. • Demir, K. • Chatti, S.
Original title: Entwicklungen und Perspektiven des Hochgeschwindigkeitzugversuchs und der dazugehörigen Technologien
Developments in and prospects of high speed tensile testing and associated technologies

Blank, Mirja
Supervisor: Tekkaya, A. E. • Witulski, J.
Original title: Entwicklung eines FEM-Modells zur Abbildung von faserverstärkten Tiefziehwerkzeugen aus Polymerwerkstoffen zur Prozesssimulation
Development of an FE-modell in order to simulate fibre-reinforced deep drawing tools made of polymer for process simulation

Braun, Alexander • Levin, Eilina • Langolf, Andreas
Supervisor: Tekkaya, A. E. • Güley, V.
Original title: Analyse der Gefügeentwicklung bei den aus Spänen stranggepressten Profilen und Vergleich zu konventionellen Verfahren
Analysis of the microstructure evolution of aluminum profiles extruded from chips and comparison to profiles extruded from as-cast billets

Eckey, Marcus
Supervisor: Tekkaya, A. E. • Becker, Ch.
Original title: Wirtschaftlichkeitsanalyse von Rohrbiegeverfahren für hydraulische Anwendungen
Efficiency analysis of tube bending processes for hydraulic application

Eriksen, Iver Ørksted
Supervisor: Tekkaya, A. E. • Steinbach, F.
Original title: Formgebungsgrenzen in der Hydroblechumformung von Kleinkanälen bei Einsatz kleiner Blechdicken
Shape forming limits in sheet hydroforming of small pipes using fine blanks

Esch, Philipp
Supervisor: Tekkaya, A. E. • M. Gharbi, M.
An Experimental Investigation of Ductile Fracture Behavior of Modern Alloys in Free Bending Process

Hoos, Michael • Kirk, Felix
Supervisor: Tekkaya, A. E. • Witulski, J.
Original title: Konstruktion eines Verschleißversuchsstandes für die Blechumformung
Construction of an experimental set-up for the analysis of wear in sheet metal forming processes

Kadifeoglu, Gökay • Ünlen, Erol
Supervisor: Tekkaya, A. E. • Güley, V.
Original title: Hochtemperatur-Kriechen der aus EN AW-6060-Frässpänen stranggepressten Aluminiumprofile
High temperature creep properties of aluminum profiles extruded from AA6060 milling chips

Kzzo, Abdullah
Supervisor: Brosius, A. • Hermes, M.
Original title: Erstellung und Verifizierung eines FE-Modells für das TSS-Profilbiegen (Erweiterung einer 2D- auf 3D-Simulation)
Development and verification of an FE model for the TSS profile bending process (extension of a 2D to a 3D Simulation)

Levin, Eilina
Supervisor: Tekkaya, A. E. • Güley, V.
Original title: Erhöhung der Wärmeleitfähigkeit von Aluminium bei Erzeugung eines Aluminium-Kupfer Verbundwerkstoffes durch das Spänestrangpressen
Increasing the heat transfer coefficient of aluminum based composite profiles hot extruded from aluminum chips by adding copper chips

Lewandowska, Marta Magdalena
Supervisor: Brosius, A. • Sebastiani, G.
Original title: Untersuchung der erweiterten IBU-Prozesskinematik mittels statistisch geplanter Versuche
Investigation on the advanced process kinematics of incremental sheet metal forming by statistically planned experiments

Pahl, Alexander
Supervisor: Tekkaya, A. E. • Becker, Ch.
Original title: Entwicklung einer kinematischen Simulation für das Inkrementelle Rohrumformen
Development of a kinematic simulation for Incremental Tube Forming

Paral, Eva
Supervisor: Tekkaya, A. E. • Pleul, Ch.
Original title: Das Labor in der ingenieurwissenschaftlichen Ausbildung
The laboratory in engineering education

Wawrosch, Arthur
Supervisor: Tekkaya, A. E. • Sebastiani, G.
Original title: Statistische Versuchsplanung in der AIBU
Statistical design of experiments in asymmetric incremental sheet metal forming

Wei, Xiaofen
Supervisor: Tekkaya, A. E. • Sebastiani, G.
Original title: Statistische Versuchsplanung in der AIBU
Statistical design of experiments in asymmetric incremental sheet metal forming

Zulkanain, Rizal
Supervisor: Abel, H.-J. (FH Dortmund)• Tekkaya, A. E.
Sebastiani, G.
Setup and realization of statistical designed experiments in incremental sheet forming

1.9 Completed Project Theses

Geese, Jan Stephan • Mrosek, Matthias
Supervisor: Tekkaya, A. E. • Pietzka, D.
Original title: Konstruktion und Gestaltung für die Halterung von Elementen für das Verbundstrangpressen
Construction and design of a carrier for elements for the composite extrusion process

Löbbe, Christian
Supervisor: Tekkaya, A. E. • Staupendahl, D.
Original title: Unsymmetrisch belastetes Profilbiegen mittels partieller induktiver Wirbelstromerwärmung anhand des TSS-Biegeverfahrens
Unsymmetrically loaded profile bending using partial inductive heating in the TSS bending process

Löper, Nadja • Wüllner, Patrick
Supervisor: Tekkaya, A. E. • Pietzka, D.
Original title: Einsatz von reibmindernden Hartstoffschichten beim Strangpressen im Miniaturmaßstab
Application of friction decreasing stiff layers for extrusion in small scale

Ngondiep, Willy • Tajedinov, Alipbay • Wüst, Valentin
Supervisor: Tekkaya, A. E. • Haase, M.
Original title: Untersuchungen zur Herstellung von Verbundprofilen mit diskontinuierlicher Verstärkung
Investigations on composite extrusion with discontinuous reinforcements

Schmidtke, Daniel
Supervisor: Tekkaya, A. E. • Pleul, Ch.
Original title: Entwicklung einer Testumgebung für die teleoperative Materialcharakterisierung PeTEX
Development of a test environment for tele-operativ material characterization PeTEX

Thom, Christopher
Supervisor: Tekkaya, A. E. • Franzen, V.
Original title: Untersuchung der Bauteiloberflächentopographie beim inkrementellen Glattwalzen
Analysis of the workpiece surface topography in incremental ball burnishing

Yuan, Xun
Supervisor: Tekkaya, A. E. • Güzel, A. • Jäger, A.
Original title: Experimentelle und numerische Untersuchung des Crashverhaltens von Aluminium-Strangpressprofilen
Experimental und numerical investigations of the crash performance of extruded aluminium profiles

2 Research for Education

Knowing that excellent education is based on excellent research and excellent research always requires excellent education, the IUL is always anxious to continuously advance engineering science education and has, therefore, initiated a number of projects. Their contents and ambition support and further the sustainable improvement of engineering education by active research on this field.

The main focus of attention inside the field of engineering education research is the scientific based investigation on learning within the engineering laboratories, which should lead to its enhancement and continuous development. Within engineering education, laboratory learning is one of the core elements. The so-called „laboratory" or "laboratory practical work" with all its varied characteristics represents an important feature in engineering education, aiming at practical experience as part of experiential learning and implementing theoretical basics. Starting with that background, the aim is to close existing knowledge gaps concerning efficient strategies to integrate modern labs. This includes the application and modification of modern didactical concepts as well as the use of innovative technologies to enhance and extend labs in a media-related and technological manner. Especially in manufacturing technology, laboratory courses are mostly based on expensive equipment, which is not easily affordable at any location.

The projects are in particular:

- TeachING-LearnING.EU
- ELLI - Excellent teaching and learning in engineering education
- IngLab - The laboratory in engineering education
- ProLab@Ing - Laboratories in engineering education with problem and project-based learning (PBL) in forming technology
- Full automation of tele-operative compression test procedure
- Integrated and research-oriented laboratory
- MasTech – Flexible modular master programme in technology

2.1 Project TeachING-LearnING.EU

Funding	VolkswagenStiftung and Stiftung Mercator
Project leader	Prof. Dr.-Ing. A. E. Tekkaya
Contact	Dr.-Ing. habil. S. Chatti

Motivation

To a large extend, social progress is determined by engineering developments. In order to fulfill this responsibility engineers do not only require an excellent professional education oriented towards state-of-the-art research, but increasingly need interdisciplinary competences such as creative thinking in a complex, interdisciplinary context, handling of diversity, and adequate communication skills. This – in combination with an ever growing demand for highly qualified engineers – issues a special challenge to European universities as to the impartation of contents and competences and the recruitment of Europe's best students for engineering training. These requirements necessitate a further professionalization of education as well as an increase in quality of engineering science studies.

Goal and Structure of the Competence and Service Center

Since June 2010 the three North Rhine-Westphalia universities

- RWTH Aachen University
  Responsible department: Center for Learning and Knowledge Management/Department of Information Management in Mechanical Engineering (ZLW/IMA)
  Board member: Prof. Dr. Sabina Jeschke (ZLW/IMA)
- Ruhr-Universität Bochum
  Responsible department: Rectorate for Internal Further Education and Consulting (IFB)
  Board member: Prof. Dr.-Ing. Marcus Petermann (Chair of Solids Process Engineering)

- Technische Universität Dortmund
  Responsible department: Center for Research on Higher Education and Faculty Development (HDZ), Prof. Dr. Dr. h.c. Johannes Wildt (Head of HDZ),
  Thorsten Jungmann (Manager TeachING-LearnING.EU)
  Board member: Prof. Dr.-Ing. A. Erman Tekkaya (Institute of Forming Technology and Lightweight Construction)

have jointly constituted and operated the competence and service center TeachING-LearnING which is financed for the period of three years through the program "Bologna – The Future of Teaching", funded by VolkswagenStiftung and Stiftung Mercator. By scombining the scientific potential of all three locations and through an interdisciplinary cooperation of general university didactics and engineering sciences, the universities see the chance to rethink and reorganize engineering sciences education and training and to give important new impetus to the formation of engineering scientific programs across Europe by a close cooperation and interaction with international partners. The competence and service center aims at promoting the engineering education's increase in quality first at national level and to create a platform for the exchange of experiences with new teaching and learning concepts. At the same time, the German and European development shall be linked and the transferability of models shall be reviewed. Further information under www.teaching-learning.eu.Ausrichtung an Kompetenzen als Learning-Outcomes

Activities in 2011

In 2011 the following activities were conducted, among others:

- On the 8th of June the first annual meeting of Teaching-LearnING.EU took place. The title of the meeting was "Next Generation Engineering Education".
- Teaching LearnING.EU promoted the first five flexible fund projects at TU Dortmund and announced additional funds for 2012.
- 49 teachers of engineering science at Ruhr-Universität Bochum and Technische Universität Dortmund participated in a total of four short workshops, the "shortcuts" in the scope of Teaching-LearnING.EU in the period from January to July.

2.2 ELLI – Excellent Teaching and Learning in Engineering Education

Funding	BMBF/DLR
Project-ID	0710511198
Contact	M.Sc. M.Eng. Ch. Pleul, né Burkhardt Dr.-Ing. habil. S. Chatti

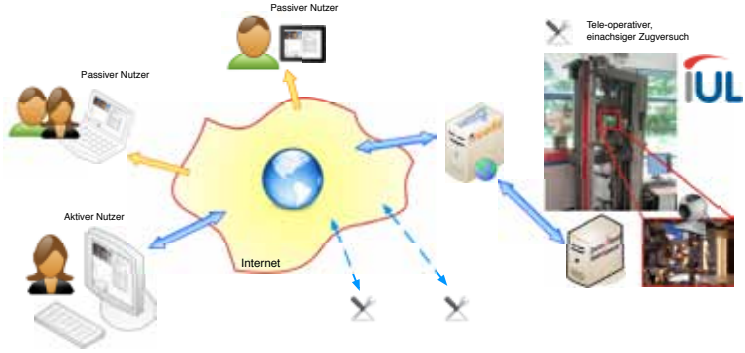
ELLI is a joint research project of RWTH Aachen University, Ruhr-Universität Bochum and TU Dortmund University. With the vision of excellently positioning German engineering education, this project aims at the improvement of the study conditions and the further development of teaching quality in engineering education. The leading faculties of mechanical engineering develop measures, which are directed to all engineering faculties of the participating sites.
In view of the emerging change of paradigms from classical engineering to the creative handling of complex questions in interdisciplinary, international teams, ELLI involves measures in the fields of virtual learning environments, support of mobility and internationality, creativity and interdisciplinarity, as well as actions, that refer to the improvement of the transitions between a student's life-cycles.
ELLI especially focusses on the problems at the beginners studying phase and also addresses the passage from studying to doctorate. ELLI provides effective approaches to solutions for acute problems like the high number of dropouts, the lack of international mobility and the low number of women among the students in engineering. Within the project standards for the second wave of the study reform (Bologna 2.0) and the way to an excellent engineering education are set.
The following strategies are followed to design the vision within ELLI:

- cooperative actions with schools to convey a clear picture of the engineering profession in industry and science to the pupils as potential students,
- give students an understanding of the big picture of engineering work through virtual learning environments and interdisciplinary, application oriented problem definitions from the beginning,
- allow stronger identification with the engineering study/profession, to reduce the number of dropouts in the first semesters,

- forward the establishment of W1 and W2 jobs and scientific research staff, to improve the staff student ratio in engineering significantly and further the student centralized design of teaching,
- establishment and networking of advice centers at the three universities, e.g. in the field of international mobility, to improve the situation of the students and study conditions,
- further increase the professional competencies and responsibility with the Bachelor to further increase the prospects of success for graduates on the labour market and in postgraduate studies and
- include special needs of minorities in engineering (migrants, disabled, women, professionally qualified) to allow these persons an unrestricted access to and successful participation in engineering studies.

At the IUL a research project will be established which will work on the focal point of "virtual learning environments" including aspects of "remote labs" and "virtual labs". Within this a "preliminary investigation to laboratories in engineering education" takes place in the first step. For this purpose, a national and international investigation will be carried out about best-practice remote and virtual laboratory concepts used in engineering education regarding existing laboratory concepts, competence-oriented learning structures and intended learning results.
On the basis of the analysis existing labs are optimized and extended. Furthermore, the analysis of the offered engineering courses including their specializations at the partners' site will take place considering their respective requirements regarding course related laboratory experiments as well as existing approaches to e-learning.
Based on the findings of the previous phase the development and extensive enhancement of remote labs and virtual labs will be carried out. According to the detected requirements, the concepts for the establishment and extension of remote labs and virtual labs are realized. Here, already gained experience from international cooperation as well as from already performed projects like "PeTEX – Platform for e-Learning and Tele-operative Experimentation" will be included. The prototypically developed infrastructure in PeTEX forms an example basis for further developments in ELLI.

Afterwards, laboratories will be built up in an iterative process at the three sites and integrated for area-wide use. For this purpose education-relevant labs and innovative processes will be developed and extended for tele-operative use. A conception which is appropriate for application and orientated towards teaching aims as well as holistic integration into the learning environment will be focused on.



Exemplary infrastructure of tele-operated experimental set-ups

2.3 IngLab – The Laboratory in Engineering Education

Funding	acatech – NATIONAL ACADEMY OF SCIENCE AND ENGINEERING
Contact	M.Sc. M.Eng. Ch. Pleul, né Burkhardt

Hands-on laboratory training courses in engineering education are traditional as well as powerful elements and have a central significance in application- and also in research-oriented study courses. This consists of:

- the practical application of theoretical models in the meaning of
- self-dependent engineering action by
- performing and analyzing hands-on experiments and
- the critical judgment of the own approaches.

Especially in manufacturing technology, hands-on laboratory training courses are performed for competence development on different levels. In this way, students are able to gain engineering know-how, and practical as well as domain-specific skills.
IngLab focuses on the enhancement of hands-on laboratory training courses in engineering education according to their requirement-, application- and competence-orientated aspects. Therefore, the state of the art is studied and the results will be structured in an accessible database. By working on the collected data an adequate complex system of categories will be developed to assess the efficiency of hands-on laboratory courses considering their contribution to employability inside and outside of the university. Together with the derived recommendations about structuring hands-on laboratory training courses in engineering education a white paper will be prepared as well as advanced training courses on laboratory didactics.
In order to carry out the project in a sustainable manner, an interdisciplinary approach is essential. Therefore, the project team commands excellent expertise in the fields of engineering as well as didactics for higher education at TU Dortmund University.

2.4 ProLab@Ing – Laboratories in Engineering Education with Problem- and Project-Based Learning (PBL) in Forming Technology

Funding	TeachING-LearnING.EU
Contact	M.Sc. M.Eng. Ch. Pleul, né Burkhardt

In the project ProLab@Ing the lecture "Forming Technology II" of the master program in mechanical engineering is supposed to be transformed into a so-called project-laboratory. Therefore, the students and their learning activities will be focused on (shift from teaching to learning). It is a sub-goal to structure the whole lecture competence-oriented, from conceptualization to the performance and to examination. Therefore, the following phases will be developed along with the step of conceptual remodeling.

After the existing competences of the students have been determined followed by a finer redefinition of the lecture, the second phase takes place with the development of certain relevant core topics. Students gather in so-called expert teams (ET). In order to make the information permanently available to all participants during the lecture, all contents are marked down and collected in a customized Wiki platform, which is at the same time a source of information for the lecture. At the end of this phase the ETs show their results to all students using the Wiki.

At the beginning of the third phase different engineering related problems are presented by the teachers. In order to work on the problems, project teams (PT) are formed. Here the only condition to be observed is that every PT has to consist of at least one member of each ET. Afterwards, each project team independently chooses one of the topics. The supervising teachers act as coach and accompany the work of the students in the project.

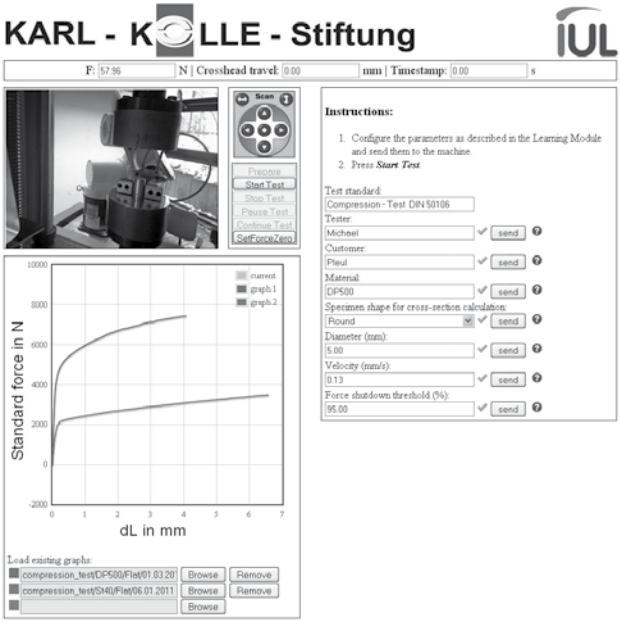
In the last phase the project teams prepare and finetune their contents in the Wiki and prepare the presentation of their work. The end of the project laboratory is marked by the scientific presentation. Following the presentation there is a question time also in order to allow a critical reflection of one's own acting.

First observations during the time the remodeled lecture is carried out, point to a high motivation when working on the problem as well as a very strong identification within the whole project. According to the students' opinion, in the engineering context of the problem, subject specific relations as well as relations across different fields are more explicit and understandable. This could lead to a much better holistical conceptual understanding of the relations within the context.

2.5 Full Automation of Telemetric Compression Test Procedure

Funding	Karl-Kolle-Stiftung
Contact	M.Sc. M.Eng. Ch. Pleul, né Burkhardt

Telemetric test facilities allow long-distance interaction with experimental units in real time. This adds to a more efficient use of test facilities. A compression test for a distant configuration and control by transferring machine parameters has been set up within the scope of the project. For this purpose, access to the control device of the universal testing machine has been achieved by extending the experimental software testXpert (Zwick GmbH & Co. KG) with the corresponding interface for remote access. The development of own software components for data processing made a two-way data exchange possible which is necessary for tele-operative use. By using the implemented six-axes robot for automatical equipping, further enhancement of flexibility is achieved. The experiment itself is configured interactively by the user through a graphical user interface.



Interactive GUI for the tele-operative compression test

2.6 Integrated and Research-Oriented Laboratory

Funding	TU Dortmund University, Faculty of Mechanical Engineering
Contact	M.Sc. M.Eng. Ch. Pleul, né Burkhardt

Taking the present situation, experiences from own teaching activities and surveys, dedicated preliminary work, and current research activities into account, the approach of research-based learning within the scope of competence-oriented courses seems to be a suitable tool.
The project "Integrated and research-oriented laboratory", which is still in progress, includes the establishment and handling of approaches for a sustainable improvement of engineering laboratories in the context of higher education. An analysis of the necessary requirements and the resulting basic characteristics of the "integrated laboratory" are carried out. At the same time the identification and qualification of possible links with other courses and the integration into the new international study program "Master of Science in Manufacturing Technology" (MMT) is investigated. The tele-operative test facilities necessary for this integrative strategy have been partly developed within the scope of the research project "PeTEX", which is funded by the EU, and are specially adapted for this purpose.
The actual engineering scientific laboratory shall not be replaced in this context. Instead, the tele-operative test facility serves as a tool to integrate practical laboratory experience into other didactic formats, e.g. lectures.

2.7 MasTech – Flexible Modular Master Program in Technology

Funding	EU, TEMPUS
Project-ID	511277-TEMPUS-1-2010-1-DE-TEMPUS-JPCR
Contact	Dr.-Ing. habil. S. Chatti

The goal of the Flexible Modular Master in Technology (MasTech), financed by EU TEMPUS Funds, is the development and implementation of a master program encouraging the mobility of teachers as well as students between universities in the partner countries (PC) Tunisia, Algeria and Morocco. A new modular curriculum will be developed and sustainable manufacturing technology programs will be established for an innovative two-year master program of excellence in manufacturing technology reforming the higher education at six universities in these countries.

The Master program consists of basic and speciality modules. The modular structure of this master (different educational modules independent from each other) gives not only consistency and flexibility to education in manufacturing but also allows an easy implementation in training programs for vocational education of manufacturing engineers to support the lifelong learning process and to easily introduce a certification process for engineers. The idea is to have a joint Master basic structure having the same educational modules in the three countries and different specialization fields in each country.

This Master program will provide the PC with the EU state of the art education in the field of manufacturing technology, resulting in more flexibility in learning and practical qualification. The enhancement of transparency and comparability of the PC educational systems and the modernization of the manufacturing technology studies according to the latest didactical strategies will also facilitate recognition of studies abroad and make the study in PC more attractive. Also the access to the labor market of graduates will be facilitated by focusing the education in manufacturing fields specific for PC industries and fortifying the university-enterprises relationship. The Royal Institute of Technology (KTH), Stockholm, Sweden, and the “Ecole Nationale Supérieure d‘Arts et Métiers (ENSAM), ParisTech, Metz, France are the European partners of the project.

3 Research

The IUL staff includes 2 chief engineers and 44 scientists, research assistants, PhD-students as well as 13 technicians and administrative staff members and 65 student assistants.

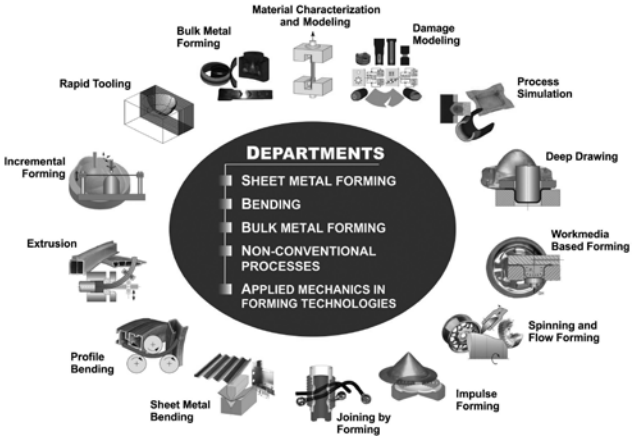
The IUL is divided into five departments:

- Sheet Metal Forming
- Bending
- Bulk Metal Forming
- Non-Conventional Processes
- Applied Mechanics in Forming Technologies

One working group has been established to support the departments:

- Measurement systems

The research projects are organized in small interdisciplinary teams. This chapter comprises an overview of research programs coordinated by the IUL. Completed and ongoing projects are presented corresponding to the five departments of the institute.



Structure of the IUL

3.1 Coordinated Research Programs

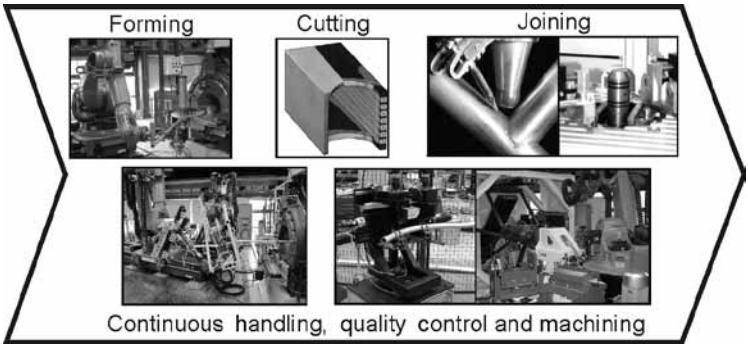
3.1.1 Collaborative Research Center SFB Transregio10

Funding	German Research Foundation
Spokesman	Prof. Dr.-Ing. A. E. Tekkaya
COO	Dipl.-Wirt.-Ing. D. Pietzka

The development of scientific fundamentals and methods for the design of integrated process chains for an automated product-flexible batch production of lightweight frame structures is the major target. . It is an exemplary model for the combination of forming, cutting, and joining by implementing an idealized process chain for the flexible production of lightweight structures.
With the beginning of the year 2011 the third and last funding period started. The main focus of this period is on the flexibility of the processes and the whole process chain.

The participating institutes and chairs are:

- IUL, Institute of Forming Technology and Lightweight Construction, TU Dortmund
- ISF, Institute of Machining Technology, TU Dortmund
- wbk, Institute of Production Science, KIT – Karlsruhe Institute of Technology
- IAM-WK, Institute for Applied Materials - Materials Science and Engineering, KIT – Karlsruhe Institute of Technology
- iwb, Institute for Machine Tools and Industrial Management, TU München
- LLB, Institute of Lightweight Structures, TU München

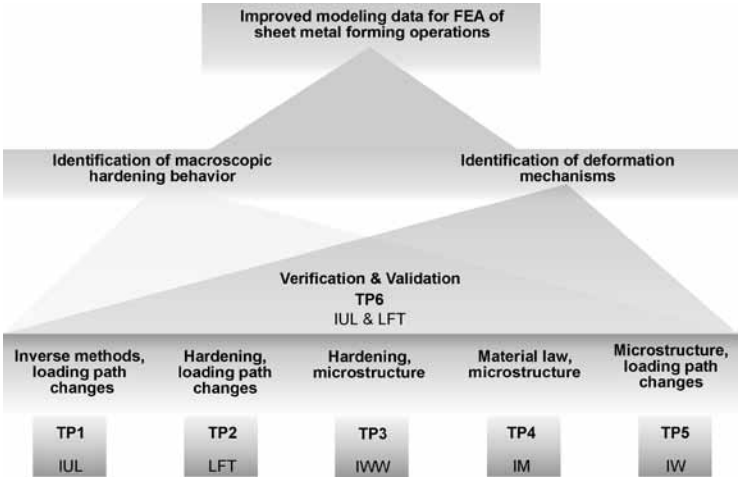


Process chain SFB Transregio10

3.1.2 DFG PAK 250
Identification and Modeling of Material Characteristics for the Finite Element Analysis of Sheet Forming Processes

Funding	German Research Foundation
Project	PAK 250
Spokesman	Jun.-Prof. Dr.-Ing. A. Brosius

The purpose of the research work is the determination of the material behavior, the identification of the required material models and the corresponding parameters in order to improve the existing methods of process analysis and process planning using finite element analysis. The focus lies on the analysis of deformation mechanisms and the activated hardening processes to obtain a basic understanding of the macro and micro structural processes.
Within the cooperation of partners from Dortmund, Hannover, Chemnitz, and Erlangen, the research project can be efficiently processed due to the specific and complementary knowledge of the partners from the field of sheet metal production, processing, and testing as well as material modeling. The project is supported by a committee consisting of experts from the automotive industry and the steel and aluminum sheet manufacturers.

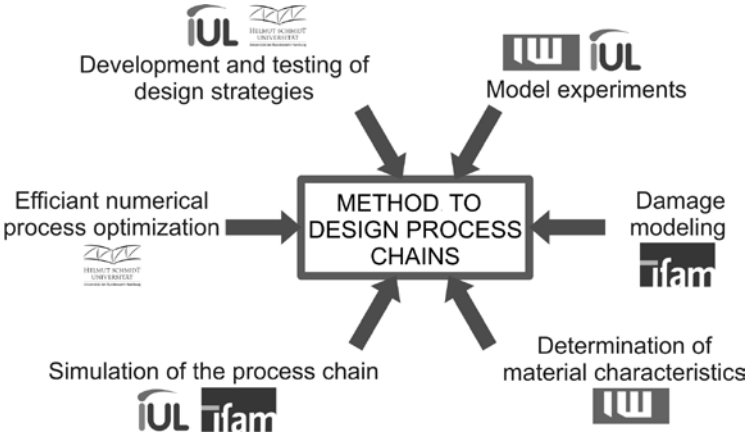


Cooperation and interaction of the subprojects within the PAK 250

3.1.3 DFG PAK 343
Development of a Methodology Regarding Combined Quasistatic and Dynamic Forming Processes

Funding	German Research Foundation
Project	PAK 343
Spokesman	Prof. Dr.-Ing. A. E. Tekkaya

The aim of this research project is to develop a methodology to design process chains composed of quasi-static and dynamic forming processes effectively. The process chains to be analyzed comprise deep drawing with integrated electromagnetic forming as well as electromagnetic tube compression with subsequent hydroforming.
Here, the challenge is to extend the forming limits of conventional one-step processes. For this, the combinations of strain path and strain rate changes, which are typical for this kind of process chains, should be systematically utilized. The focus is put on the analysis of forming mechanisms, the work hardening and fracture effects as well as the simulation and optimization of these effects. Covering these various research areas is achieved by the cooperation with the Chair of Theory of Electrical Engineering and Computational Electromagnetics (Hamburg), the Institute of Applied Mechanics at RWTH Aachen, and the Institute of Materials Science at Leibniz Universität Hannover.



Collaboration of project partners

3.2 Department of Bulk Metal Forming

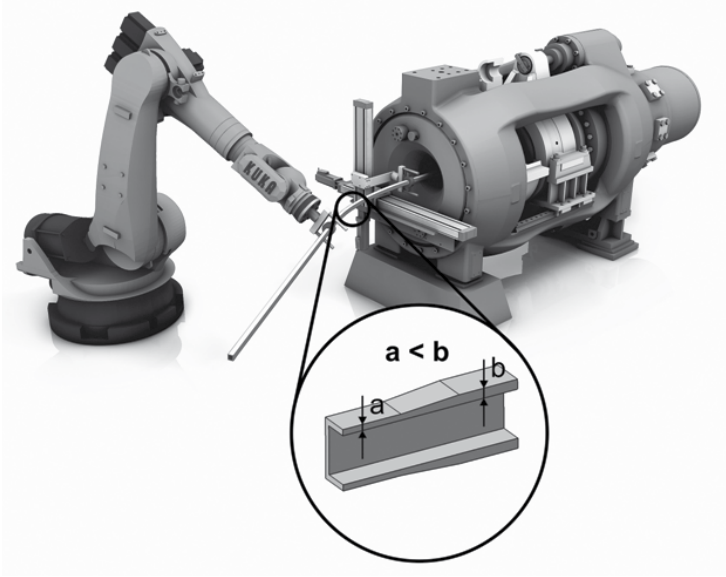
Head Dipl.-Ing. Andreas Jäger

The department of bulk metal forming focuses on research and development of processes for the production of lightweight and locally property or functionally adapted structural components by hot extrusion and cold forging. Besides processing of light materials like aluminum or magnesium, the manufacturing of composite parts by innovative processes und process combinations, developed at the IUL, is under examination. For example, special dies or specially prepared billets are used to feed reinforcing elements continuously or partly into the matrix material during hot extrusion for increasing the mechanical properties. Besides improving the mechanical properties like strength or stiffness, the embedding of functional elements is aspired. Co-extrusion is used to produce components characterized by high strength and, at the same time, a good corrosion resistance. For the variation of the shape of extruded profiles, four different processes are under investigation and development at the IUL. Curved profile extrusion is used to produce three dimensional curved profiles by deflecting the material flow in hot extrusion. Currently, this process is expanded to the manufacturing of profiles with variable wall thickness by making use of moveable tool elements. By the combination of hot extrusion and electromagnetic compression, profiles with locally adapted cross section geometry can be manufactured. Furthermore, aluminum chips are recycled by profile extrusion without the need for a re-melting. By the combination of chip extrusion with a subsequent ECAP process (Equal Channel Angular Pressing), the microstructure can be modified. In cold metal forming, innovative processes like the combination of deep drawing and cold forging for the manufacturing of functionally graded parts are under development or, like the hollow lateral extrusion, are analyzed by numerical methods.
Besides the development of new processes or process variants, processes well established in industry are under investigation. The aim is to understand the mechanisms and interdependencies for expanding the process limits or to prevent failures and scrap. Examples in the area of hot extrusion are the prediction of the material flow and the optimization of the tools or the extension of the process limits in hot extrusion by applying local die cooling. In the field of cold metal forming, the process chains of cold forging and wire drawing are analyzed in order to minimize distortion.

3.2.1 Multi-Axis Curved Profile Extrusion

Funding	German Research Foundation
Project	SFB/TR 10 • Subproject A1
Contact	Dipl.-Inform. A. Selvaggio

This project deals with the further development of the multi-axis curved profile extrusion process and represents the beginning of the process chain which is examined in the Collaborative Research Center Transregio10. One main objective in the third funding period of this project is the development of the process “extrusion of profiles with variable wall thickness” and the combination of this process with the “multi-axis curved profile extrusion”. Within the extrusion of profiles with variable wall thickness the wall thickness of extruded profiles can be modified during the extrusion process by making use of moveable tool elements, which are used to modify the position of the bearings. In the figure below, the combination of both processes is shown schematically.

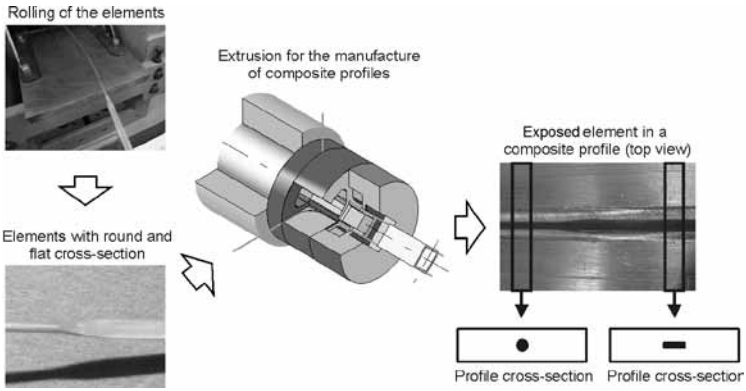


Extrusion of 3D-curved profiles with variable wall thickness

3.2.2 Composite Extrusion

Funding	German Research Foundation
Project	SFB/TR 10 • Subproject A2
Contact	Dipl.-Wirt.-Ing. D. Pietzka

The major aim of the project is the process development for the embedding of reinforcing and functional elements in structural parts for lightweight applications of aluminum alloys by the extrusion process. The elements are fed in during extrusion into special porthole dies and are embedded continuously in the profile. In present work for the flexibilization of the process for example reinforcing elements with varying cross-sections are fed in. The cross-sections of the elements can be changed during extrusion to manufacture profiles which fit to the demands on structural parts. Different forming processes like rolling, reducing, structuring and punching are analyzed with regard to the formability of the high strength elements and the suitability for the integration in the composite extrusion process. In experimental trials a discontinuously rolled wire with round and flat sections was embedded in a flat profile.

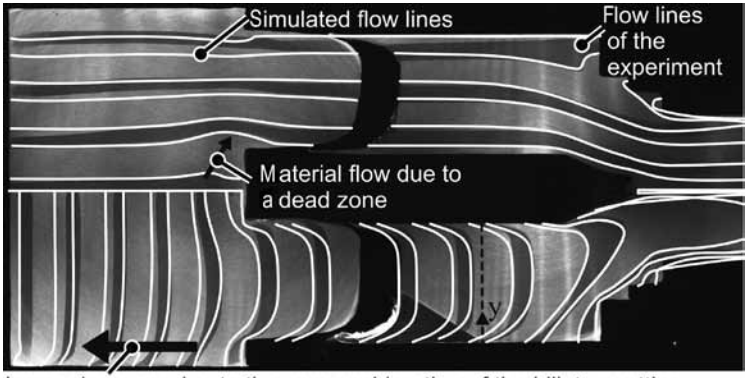


Manufacture of composite profiles with varying cross-sections of the reinforcing elements

3.2.3 Integral Design, Simulation, and Optimization of Extrusion Dies

Funding	German Research Foundation
Project	SFB/TR 10 • Subproject B1
Contact	Dipl.-Ing. Th. Kloppenborg

The project deals with the integral design, simulation, and optimization of extrusion dies to manufacture profiles with embedded functional elements as well as profiles with varying wall thicknesses over the profile length.
Previous investigations in the last years focused on the analysis of the steady state extrusion process. Currently, simulations are carried out to analyze transient effects of the process such as the pressing on. Last year the simulation results of different modeling formulations (Euler and Lagrangian formulation) were compared and additionally verified by a visioplastic analysis of the process. The aim was to check how accurate the numerical calculations are in the case of material flowprediction. It was found that in the case of realistic tribological boundary conditions both formulations calculated the same velocity field. The visioplastic analyses of the material flow showed that the numerical results are in very good agreement with the experiments.

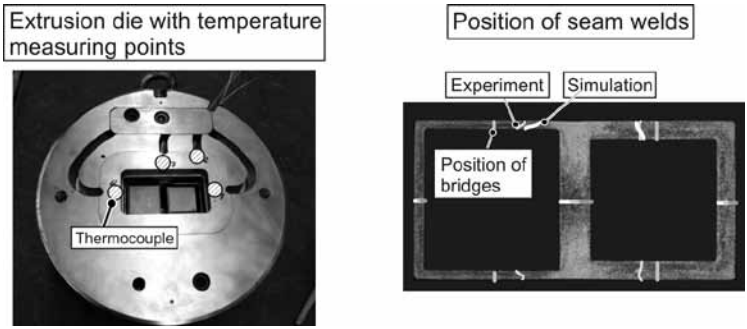


Comparison of the calculated flow lines in HyperXtrude with the flow lines of the visioplastic analysis

3.2.4 Efficient Extrusion Simulation for Industrial Applications

Funding	German Research Foundation
Project	SFB/TR 10 • Subproject T6
Contact	Dipl.-Ing. Th. Kloppenborg
	Dipl.-Ing. M. Schwane

In this transfer project the basic knowledge of hot extrusion simulation, which was developed within the scope of the SFB/Transregio10, is put to use in industrial applications in order to increase the efficiency of the die design process as well as to improve the quality of extruded profiles by means of numerical tools.
To validate the predictive accuracy of the utilized commercial FEM codes, special extrusion dies were developed which allow the precise temperature measurement of profile and tool. The experimental tests were conducted in close collaboration with participating extrusion companies. Furthermore, the material properties of the produced profiles were determined by accompanying material testing. Currently, the comprehensive experimental data is used to improve the numerical prediction of seam weld quality. Another important aspect is the numerical optimization of the investigated extrusion processes.

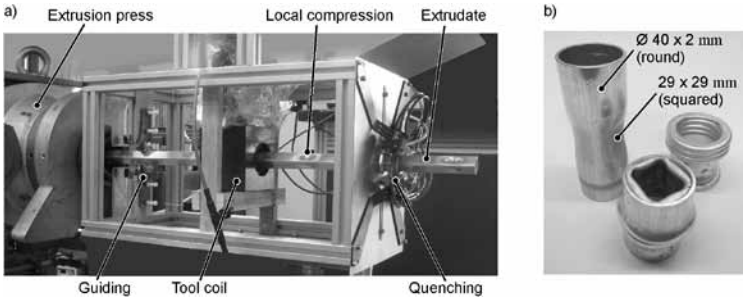


Extrusion die used for the validation of process simulation and numerical prediction of the seam weld position

3.2.5 Thermomechanical Processing of Aluminum Alloys after Extrusion

Funding	German Research Foundation
Project	SFB/TR 30 • Subproject A2
Contact	Dipl.-Ing. A. Jäger • M.Sc. A. Güzel

By the integration of thermo-mechanical forming and heat treatment operations into the process chain of extrusion, products with locally adapted properties are to be manufactured. In connection with the resulting microstructure, profiles with specifically adjusted properties can be manufactured. Aim of the current, second phase of the project is to improve the process combination of hot aluminum extrusion, electromagnetic compression, and heat treatment technologically and to model it numerically for the production of property-optimized products. To analyze the forming history of the workpiece, a new measuring setup was developed for detecting the radial workpiece displacement in compression. By using different field-shapers and mandrels for electromagnetic compression, products of different geometries can be manufactured. A possible application might be a “crashbox” with as a crashabsorbing element in a car bumper system, which will be characterized in future.

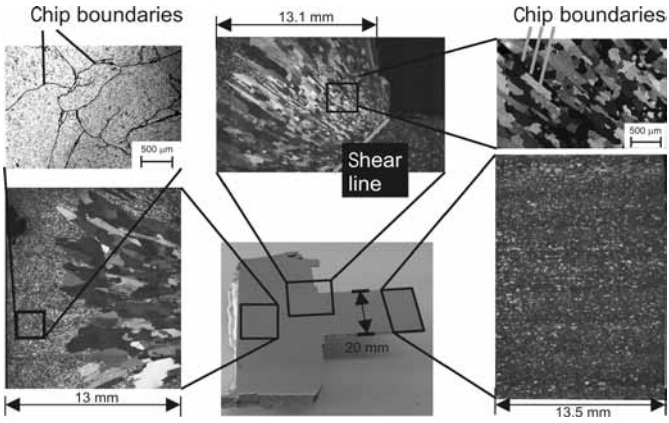


a) Extrusion with in-line electromagnetic compression, b) application “crashbox”

3.2.6 Recycling of Aluminum Chips by Metal Forming

Funding	German Research Foundation
Project	TE 508/12-1
Contact	M.Sc. V. Güley
Status	Completed

The main topic of this research project that ended in May 2011 was the determination of main affects on profiles directly extruded from aluminum machining chips. The investigations revealed that the process parameters material flow, extrusion ratio, and billet temperature defined the mechanical properties of the extrudates. Using higher extrusion ratios and higher billets temperatures, it was possible to reach higher strength and ductility of the aluminum profiles. By adjusting the material flow in order to increase the pressure on the chips and, thus, providing means for higher bonding quality, it was possible to increase the ductility of the extrudates remarkably. Using the know-how acquired in this project, working out a precise definition of the chip extrusion process using the connection between the process control parameters, tool design, and product quality is aimed at.

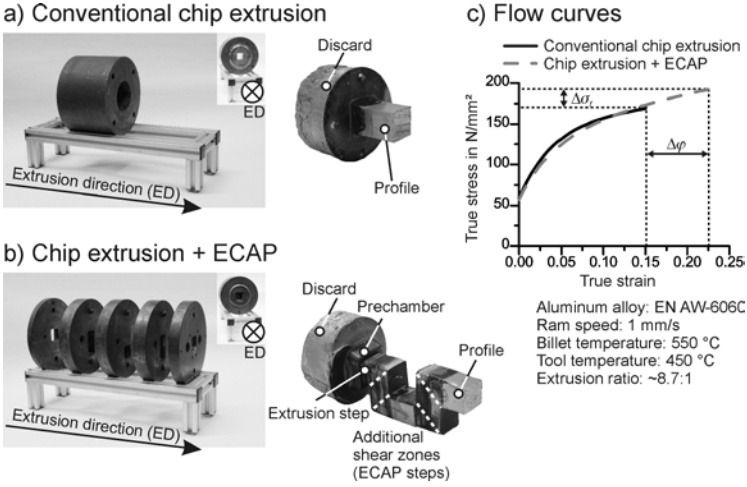


Images from different portions of press rest from extrusions from chips through the flat-face die showing the microstructural evolution

3.2.7 Enhancement of the Extrusion of Aluminum Chips by an Integrated ECAP Process

Funding	Graduate School of Energy Efficient Production and Logistics
Contact	Dipl.-Wirt.-Ing. M. Haase

The aim of this project is the enhancement of the extrusion of aluminum chips by integrating an equal channel angular pressing (ECAP) tool into an extrusion tool. Instead of a conventional re-melting process, the aluminum chips are solid-state-recycled through cold compaction and hot extrusion.
Due to the integration of the ECAP process in the extrusion process, microstructure and mechanical properties of the chip-based profiles can be influenced without a further change in the cross section of the profile.
First results show an increase in strength and ductility compared to chip-based profiles solid-state-recycled by means of a conventional extrusion tool.

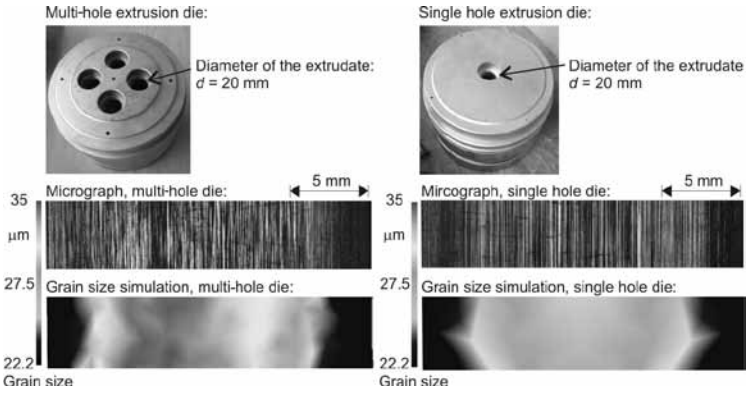


a) Conventional chip extrusion, b) Chip extrusion + ECAP, c) Flow curves

3.2.8 Microstructure Evolution during Extrusion

Funding	German Research Foundation
Project	FOR 922 • Subproject 1
Contact	Dipl.-Ing. A. Foydl
Status	Completed

Until June 30, 2011, the IUL was member of the DFG research group „extrusion“ together with the institutes IW and IFUM of Leibnitz Universität Hannover and the LWT of the University of Rostock. The aim of the project was the development of a methodology to predict mechanical properties based on the tool geometry as well as the extrusion process and the heat treatment parameters.
In this subproject the grain morphology in dependence on the history of temperature, strain and strain rate was examined. A correlation between strain and grain size during the process could be found by means of a reference test. An empirical equation could be set up which was implemented into a finite element code through a user subroutine. The finite element calculation was validated by the of extrudates which were produced with a 10 MN extrusion press and two different extrusion dies.

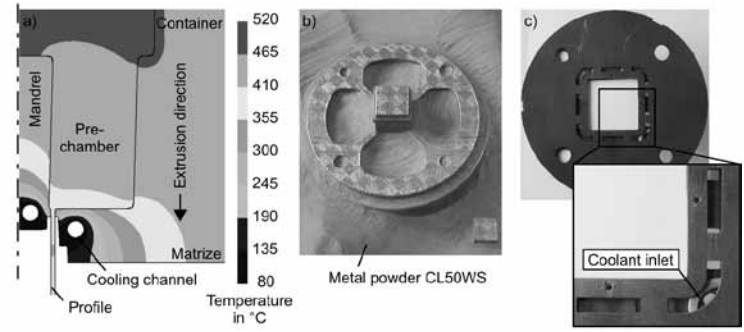


Micrographs and grain size simulation of two different extrudates

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

Funding German Research Foundation
Project TE 508/27-1
Contact Dipl.-Wirt.-Ing. R. Hölker

The aim of this project is to extend the process limits and the productivity of hot extrusion by the introduction of conformal cooling channels in the die close to the bearings and to investigate the interactions between billet, die, and process parameters in order to control the extrusion process.
Investigations using a near-surface die cooling during the extrusion process revealed that the place of inserting the cooling channels right next to the die bearings as well as the cooling strategy have a strong influence on the profile´s exit temperature and, therefore, also on its surface properties. To accomplish such a near-surface cooling, the dies will be manufactured by technologies of rapid tooling. Due to differences in the process the layer-laminated manufacturing methods will be used for plain parts, like the die cap of an extrusion die, and the powder metallurgy based methods (LaserCusing) will be used to build geometries with very high complexity, like the mandrel of the extrusion die.

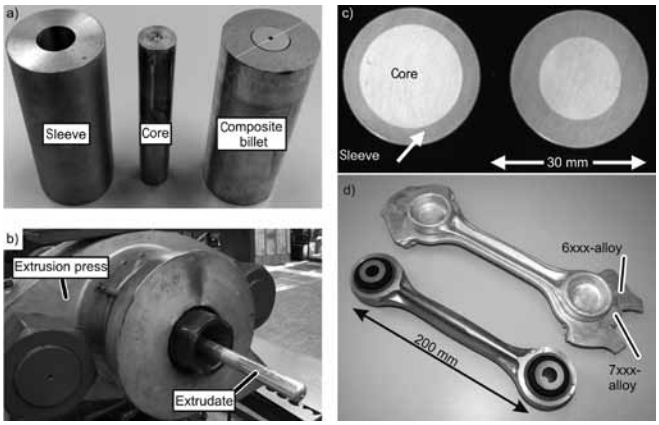


a) Cooling channel close to the die bearings (FEM), b) mandrel of an extrusion die manufactured by selective laser melting, c) layered extrusion die with cooling channels

3.2.10 Development of a Hybrid Forging Process for Highly Stressed Vehicle Components in Lightweight Construction

Funding	BMBF - ZIM/AiF
Project	KF2198102CK9
Contact	Dipl.-Ing. A. Jäger
Status	Completed

In this project, the production and subsequent treatment of composite materials have been investigated. Within the scope of the cooperative project, the co-extrusion process was used to produce composite semi-finished products for a hybrid forging process, developed by the project partner LEIBER Group GmbH & Co. KG, Emmingen. The hybrid-forged products have increased the lightweight potential by high structural strength and corrosion resistance at low density. To this end, the material flow behavior during co-extrusion was analyzed and designed for optimum composite properties. The effect of initial billet and tool geometries determined by FEM simulations was validated by experiments. The coextruded profiles were manufactured by IUL. Having these profiles as semi-finished products, prototypes in the form of a suspension rod were manufactured and tested by Leiber Group. Enhanced mechanical properties were achieved in the case of novel composite forging of the products compared to the monomaterial forgings.

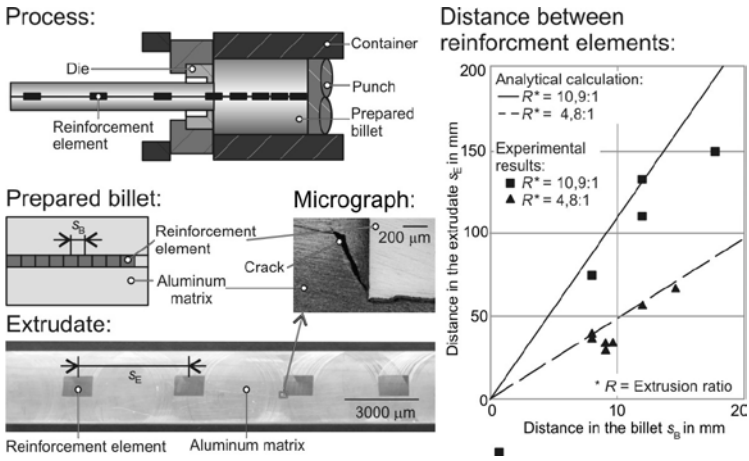


a) Initial composite billet, b) Extrusion press, c) Distribution of core and sleeve components in the cross-section of coextruded profile, d) Hybrid-forged prototype

3.2.11 Component Optimization by Forging of Composite Aluminum Extrusions

Funding	German Research Foundation
Project	TE 508/17-1
Contact	Dipl.-Ing. A. Foydl

With the scope of this project the manufacture and further processing of partially reinforced profiles within the process chain extrusion and hot forging is analyzed in cooperation with the Institute of Forming and Metal Forming Machines at Leibniz University Hannover. The reinforcement exists in non-stirred but discrete form.
The focus of this research activity at the IUL is on the positioning as well as on the embedding quality of the reinforcing elements within the extruded product. For this purpose, for example, reinforcements with different geometries were embedded in two different rods. The length and the position of the reinforcement elements inside the billet do have an influence on the distance of the elements within the extrudate. In the cases studied the shape of the elements had no significant influence on the position in the extrudate. Reinforcements with sharp edges can lead to cracks in the aluminum matrix.

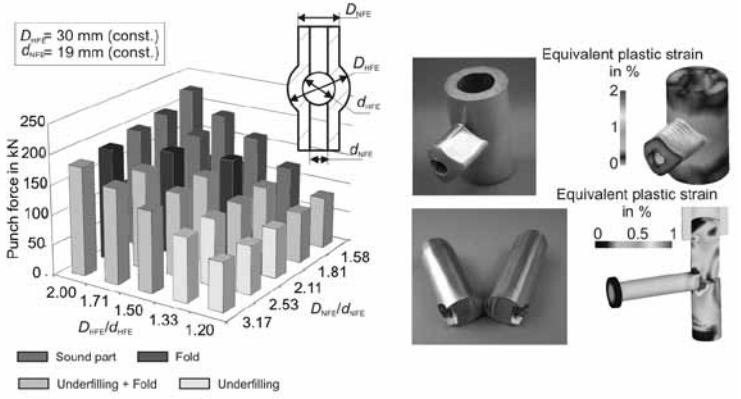


Distance between the reinforcements elements in an extrudate

3.2.12 Basic Investigations on Hollow Lateral Extrusion of Additional Shape Elements

Funding	German Research Foundation
Project	TE 508/13-1
Contact	Dipl.-Ing. M. Schwane
Status	Completed

Within this joint project with the Institute for Metal Forming of the University of Stuttgart the hollow lateral extrusion of tubular billets has been investigated. This new process allows the production of hollow components by cold forging.
By means of the developed tool concept components with two and four axisymmetric additional shape elements could be manufactured using billets made of EN AW-6060 aluminium alloy as well as C4C steel. Numerical and experimental analyses revealed that the geometrical relations (ratios of wall thicknesses and diameters) mainly influence the process limits which occur in terms of folding and underfillings. With regard to components having only a single additional shape element, the load of the main mandrel turned out to be critical.
In the envisaged follow-up project a process variant shall be investigated which allows the production of hollow shape elements with closed front ends.

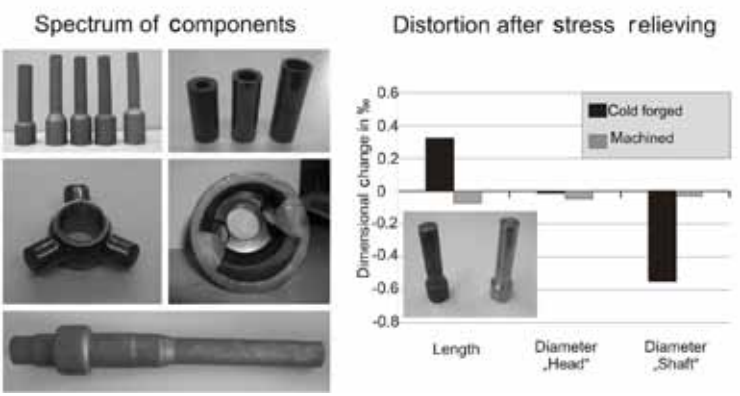


Influence of geometrical relations in hollow lateral extrusion of symmetric components and failure of main mandrel in a non symmetric part

3.2.13 Analysis of the Active Correlation between Heat Treatment and Distortion of Cold Forging Workpieces

Funding	AiF ZUTECH
Project	309 ZN
Contact	Dipl.-Ing. S. Hänisch
Status	Completed

Cold forging allows an economical production of complex and dimensionally accurate workpieces in large quantities. During the heat treatment often following the cold forging process the component can be distorted for reasons not yet clearly resolved. Within the scope of a joint project of IUL and IWT the relations between cold forging, heat treatment and distortion have been investigated.
In extensive series of experiments with increasingly complicated components, different parameters such as material, deformation, or lubricant were varied. The component properties, also supported by the FEM simulation analysis, were analyzed and the main factors having an effect on on distortion of cold-forged components were identified. It was found that the material, the plastic strain, and the cooling rate during hardening have significant influence on the diameter and length change of the components.

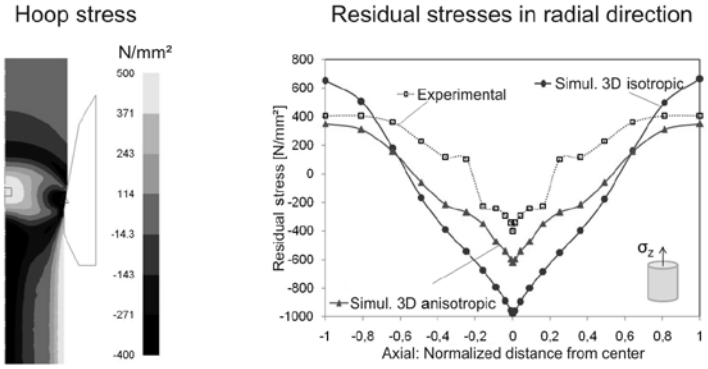


Investigated spectrum of components; influence of the production process on distortion

3.2.14 Investigation and Improvement of a Manufacturing Process Chain Covering Cold Drawing Processes through to Induction Hardening

Funding	German Research Foundation
Project	TE 508/18-1
Contact	Dipl.-Ing. S. Hänisch

Within the scope of this German-Brazilian joint project, each production step of the cold drawing process, from initial material to the drawing himself up to the induction hardening is investigated experimentally and numerically and the reason for distortion is identified in order to provide remedy in the future. The subtask of the IUL consists in the implementation of FEM simulations of the drawing process considering temperature influence and partially anisotropic material behavior to identify the relationship between residual stresses and distortion and to derive potentials for improving the process chain. In addition, disturbances as eccentricity, angular errors, and inhomogeneous distribution of lubricants are simulated to examine their effects and to predict distortion.



On the left: FEA simulation of cold drawing, on the right: comparison of experimentally and numerically determined residual stresses

3.3 Department of Sheet Metal Forming

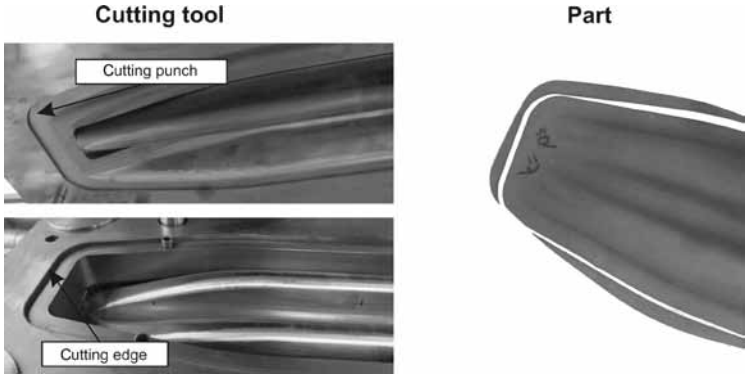
Head Dipl.-Ing. Jörg Witulski

The department deals primarily with both, the research of existing processes and development of new processes as well with the analysis and characterization of high-strength sheet material used. Majory objectives are to enlarge and deepen the process knowledge in order to promote especially new technology and to enable an efficient process layout. Beside the requirements of lightweight construction in relation to a consistent weight reduction with a simultaneous functional compliance, the motivation is given by the need to shorten process chains for ecological and environmental reasons.
For instance, a project which deals with the process layout of hot stamping analyzes the use of an integrated punch process in the hot stamping process. A second project showed by feasibility studies the transferability of the hot stamping process to tube forming. The results are the basis for a new project which has the objective to model the hot forming process of tubes in order to analyze process limits. Further projects deal with hydroforming, too. Hence, hydroforming of organically coated sheet metal is being investigated as well as the possibility for an efficient manufacturing of solar absorbers by combining cold roll bonding and hydroforming. The process combination of injection molding and hydroforming is used to realize metal-plastic components. For this purpose, process models for the process simulation are developed and the manufacturing concept is analyzed. Further focuses of the department are investigations dealing with the forming of high strength steels. Technologically, the substitution of conventional tool materials by concrete or by hard material coated polymers is analyzed. Additionally, a main aspect is the improvement of modeling springback effects and enhanced material characterization. In order to reduce computational times, fast algorithms are developed.

3.3.1 Process Design of Hot Sheet Metal Forming

Funding	German Research Foundation
Project	FOR 552 • Subproject 3
Contact	Dr.-Ing. H. Karbasian
Status	Completed

The aim of this project was the research and development of strategies for the process design of hot forming to realize an improvement of formability restrictions in hot forming processes. For this purpose, the FE modeling of thermo mechanical effects in hot forming were investigated in a first step to allow an effective simulation. Based on this investigation, the causal connections between the process parameters were determined and summarized in guidelines for process design. For experimental verification a demonstrator tool was developed within this project which enables a subsequent cutting process in addition to the hot forming process.

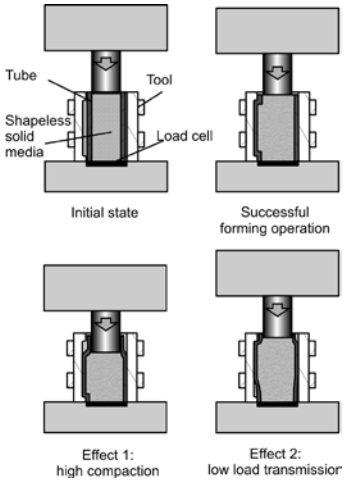


Integrated cutting tool and cut hot-formed part

3.3.2 Hot Stamping of Tubes and Profiles with Shapeless Solid Media

Funding	FOSTA
Project	P 902
Contact	Dipl.-Ing. Th. Mennecart
Status	Completed

Hot stamping is a well-established process for the production of parts with very high strength, which is generally used for sheet parts. In this research project, which was carried out in close collaboration with the Chair of Forming and Machining Technology of the University of Paderborn, this process was applied to forming tubes made of the material 22MnB5. Shapeless solid media were used in sizes between 0.09 mm and 1.6 mm, which are able to induce high pressures into the tube. So these media are able to form the tubes and even to reduce shrinkage during forming. Contents of this project were the selection of possible shapeless solid media, investigations on the influence of the media on the cooling rates, influences on forming abilities, and the influence on the surface quality. The results show that it is possible to form and harden the tubes with these media. Depending on the kind of shapeless solid media, a reuse of the medium is possible which results in a cost-effective process.

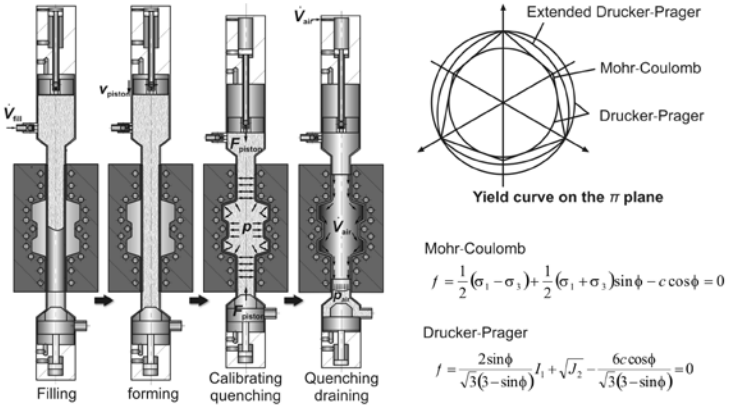


Possible results after forming with shapeless solid media

3.3.3 Modeling of Press Hardening of Lightweight Structures Using Shapeless Solids as Forming Media

Funding Graduate School of Energy Efficient Production and Logistics
Contact M.Sc. H. Chen

Press hardening of boron micro-alloyed steel sheets 22MnB5 is widely used in automotive industries, which need to fulfill the increasing requirements on crashworthiness and lightweight design. However, the hot stamping process is state of the art, while hot tube hydroforming for complex parts like tubes or profiles is limited by the used medium. Using granular materials allows high temperatures and reduces the risk of leakage.
The aim of this project is modeling of the hot tube hydroforming process using granular materials as forming medium. In order to model the granular materials, the suitability of a Mohr-Coulomb and a Drucker-Prager model will be investigated and validated. Experiments will be carried out to evaluate the frictional behavior and mechanical properties of the granular materials. Due to the non-hydrostatic pressure distribution of the granular materials, an optimization of the tools or process procedures should be considered.

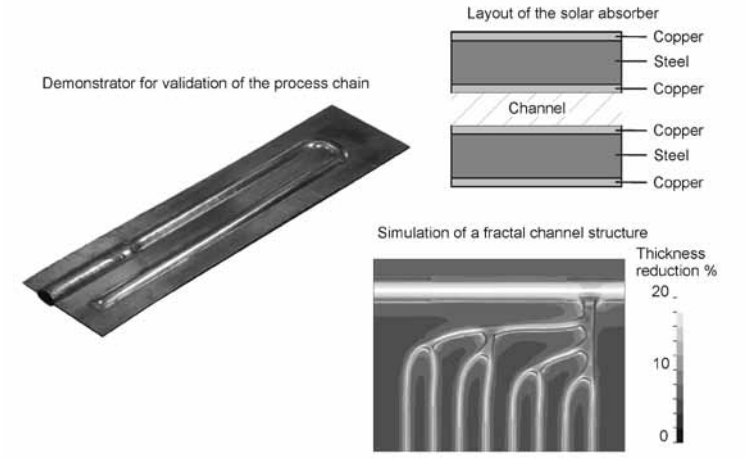


Press hardening of tubes and profiles using shapeless solids and the material models of granular materials

3.3.4 Processing of New Solar Absorbers in Steel Design Based on Partial Cold Roll-Bonded Hybrid Semi-Finished Parts

Funding	AiF ZUTECH/FOSTA
Project	ZN 339/P 820
Contact	Dipl.-Ing. F. Steinbach

In contrast to conventional copper sheet metal-copper tube design, here, absorbers are manufactured by a fast, nearly continuous production process which consists of cold roll bonding and subsequent hydroforming, similar to symmetric hydroforming of sheet metal pairs. The outcome of this is a hybrid structure in which the water channels are embedded between roll bonded copper-steel-copper sheets. By using such a process chain it is possible to create a channel design as a quasi-fractal structure (FracTherm®, together with Fraunhofer ISE). Such a structure has the benefit of a uniform flow distribution with a reduction of the pressure drop and the required energy for the pump of the solar system.
Special focus is put on the geometry of the channel cross section cuts as here mainly plain strain occurs. Via a testing tool and FE simulation the high pressure forming of different geometries is examined and optimized. The process chain is verified by a demonstrator.



Developing a new solar absorber – highlights

3.3.5 Manufacturing of Positively Locked Polymer-Metal-Hybrid Parts by Combining Injection Molding and Sheet Metal Forming

Funding	German Research Foundation
Project	GRK 1378/1 • Subproject 9-2
Contact	Dipl.-Ing. B. Rauscher
Status	Completed

The process combination of injection molding and hydroforming is applied in order to produce lightweight, functional metal-plastic composite parts. A key function of this manufacturing concept is the plastic component of the hybrid part which acts as working medium during the forming process plus, in solid state, provides a stiffening structural as well as functional component of the hybrid part.
In this project, joining of sheet metal and plastics has been realized by positive locking. Here, the semi-finished sheets feature cuttings and perforations to allow a material flow of the plastic through the sheet during the molding process. Different experimental investigations show the possibility to produce hybrid plastic-metal-structures with high mechanical load capacity.
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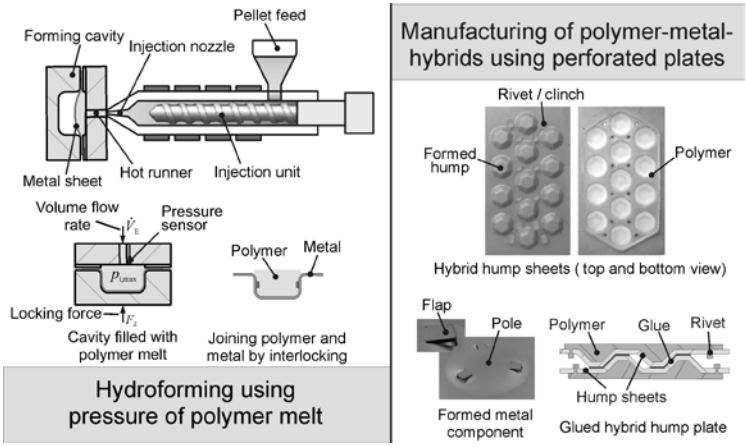
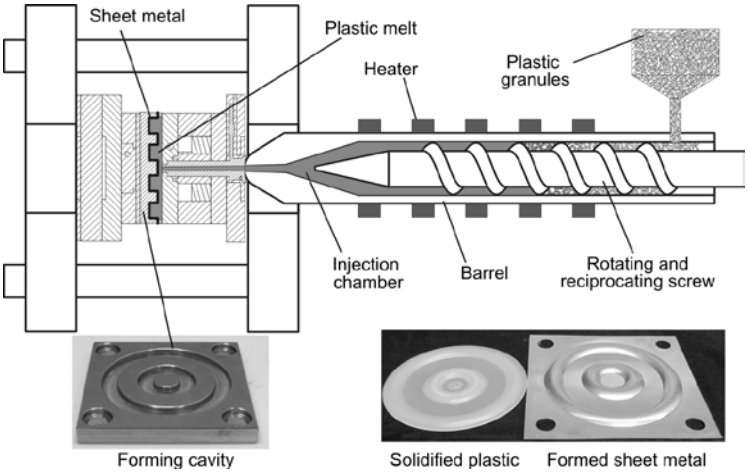


Process principle and produced parts using an integrated manufacturing process of forming and injection molding

3.3.6 A Fundamental Investigation on the Combined Injection Molding – Sheet Metal Forming Process

Funding	German Research Foundation
Project	GRK 1378 • Subproject 9-1
Contact	M.Sc. M. M. Hussain
Status	Completed

In this project, the combined injection molding-sheet metal forming process has been investigated. The basic understanding of the combined process has been developed by experimental as well as by numerical means. The forming-molding tool equipped with special measurement techniques was used to observe the online progress of combined process variables. After investigating polymer-injected free forming and cup forming processes, research was extended to include more complex shapes, i.e. center-gated channel forming. The previously developed tool was enhanced to investigate the non-hydraulic response of the viscous polymer. The process variables including viscosity, injection rate, and flow geometry were observed to have a significant effect on the forming process. The thermo-mechanical FE model developed previously for free forming processes was used to simulate new forming shapes.

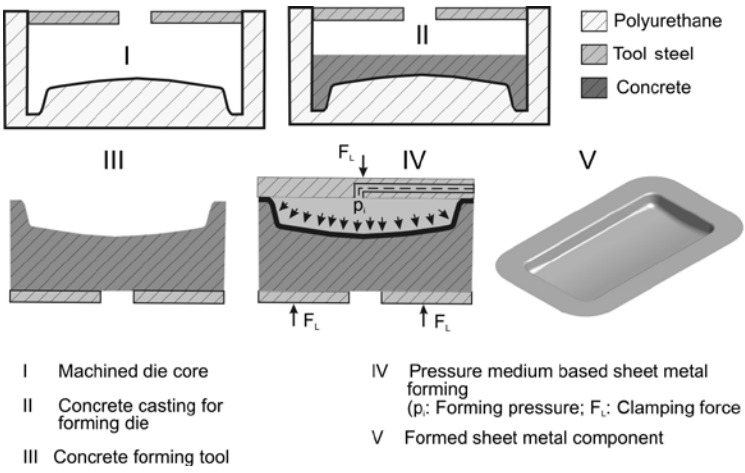


The center-gated plastic injection process for forming of concentric channels

3.3.7 Development of Concrete Dies for Sheet Metal Hydroforming

Funding	German Research Foundation
Project	TE 508/7-2 (formerly: KL 619/28-1)
Contact	M.Sc. M. M. Hussain

Forming tools made of concrete for the manufacturing of sheet metal parts by hydroforming for prototype and small batch size production are being developed. In the first funding period a fine grain concrete matrix reinforced by steel fibers could be developed which is adequate to be used for hydroforming of simple geometries. For the second funding period this technology will be extended to produce shapes consisting of large surface areas. The loading capacity of the tool material is to be determined by investigating the stress-strain behavior of concrete under combined tensile and compressive stress state conditions. Currently, the manufacturing of a concrete forming die for large-area panels and the testing of concrete as die material is under progress.

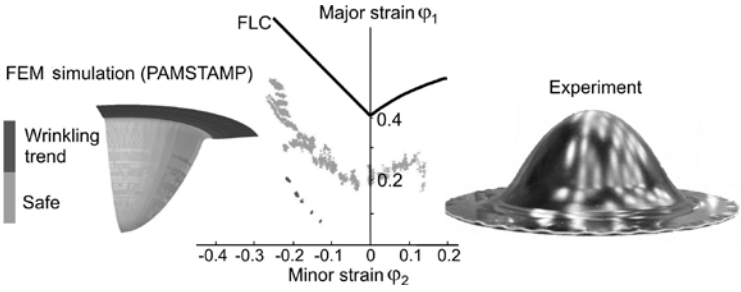


Process chain for producing large area sheet metal formed panels using a die made of high performance concrete

3.3.8 Process Design for the Forming of Organically Coated Sheet Metal

Funding	German Academic Exchange Service
Contact	Dr.-Ing. H.-D. Pham
Status	Completed

The aim of the project was the investigation of the forming behavior of organically coated sheet metal, focusing on changes of the optical properties, i.e. gloss degree depending on the process parameters. Experimental results detected within this project have shown that the gloss reduction of the coated surface is basically caused by the strain states and strain level imposed on both steel substrate and coating layer. In order to exactly predict the coating failures, the forming limit curve (FLC) of the coating was determined. By using FLC of the coating, the formability concerning the optical properties of the coating layer was predicted with the help of finite element simulation. The obtained results were finally validated by hydro-mechanical deep drawing of a demonstrator geometry, as shown in the figure.

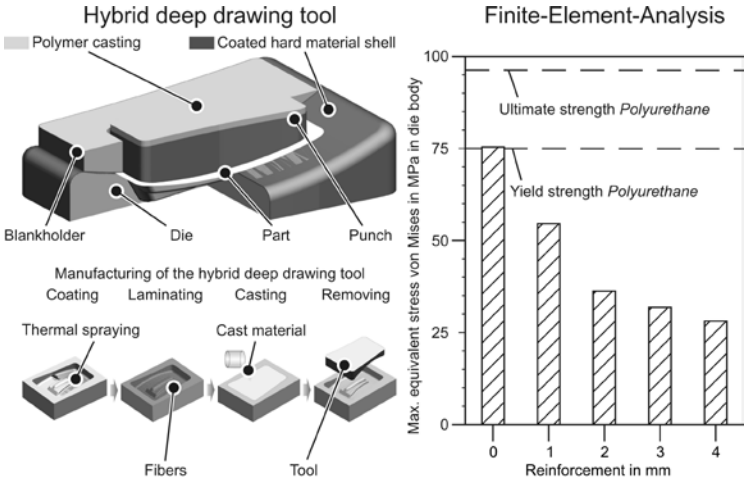


Hydro-mechanical deep drawing of demonstrator geometry

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

Funding	German Research Foundation
Project	SFB 708 • Subproject C1
Contact	Dipl.-Ing. J. Witulski

Within the Collaborative Research Center Program SFB 708, this project is an alternative approach to manufacture forming tools featuring a high wear resistance. A methodology for the rapid production of drawing tools to form free-form shaped sheet metal parts made of high-strength steel is developed for the use in small up to medium batch size production. Hard material shells are thermally sprayed on an original mold and supported by a polymer. The bonded shell is removed from the original mold and acts as the surface. Reinforcement fibers are used to increase the strength of the polymer.
Finite-element analysis demonstrates that the use of fibers which are placed directly below the coating avoids critical stresses in the polymer tool body. Deep drawing tests show that the tool design is adequate to form high strength steels. Due to the lower stiffness of the tool compared to conventional tool setups, a more homogeneous contact pressure is realized, which reduces tryout times.

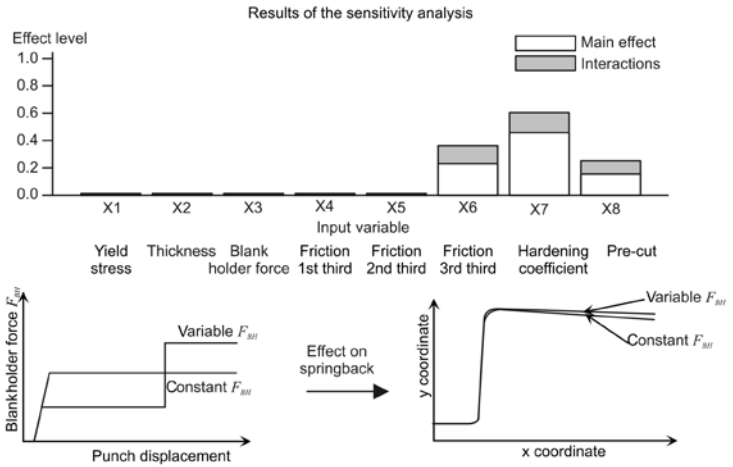


Process chain for the manufacturing of the hybrid deep drawing tool and Finite-Element-Analysis

3.3.10 Strategies for Springback Compensation

Funding	German Research Foundation
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 and stretch drawing processes with respect to dimensional accuracy and part failures. Stochastic influences such as the variation of coefficient of friction and deterministic variation of blankholder force etc. will be considered and implemented into finite element modeling of the forming process using a functional input.
The FEM with functional input serves as the basis for a more realistic simulation as well as improved understanding of the process. For the implementation of this technique, first of all the process design is prepared using an Optimal Latin Hypercube Design which is then applied in a Kriging model based Metamodel. The sensitivity analysis taking the time dependency of process parameters into account shows that the highest impacts on springback effects are given by the hardening coefficient, the pre-cut of the blank, and the friction coefficient in the last third of the process.

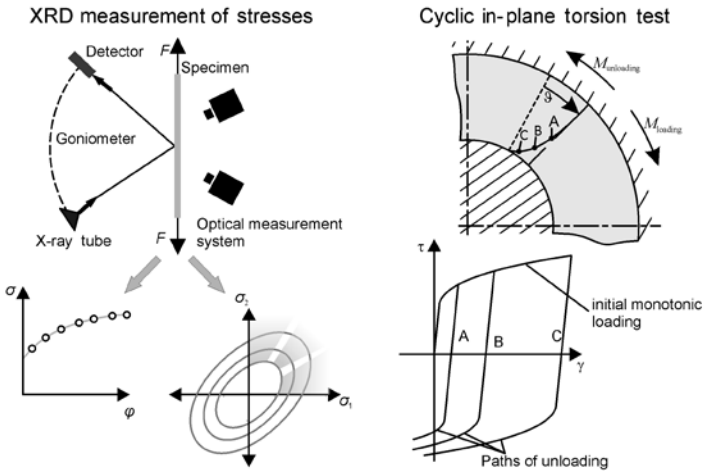


Time-dependent incremental simulations and statistical models

3.3.11 Identification of Material Models as well as Corresponding Parameters by Means of the Inverse Method and Novel Experimental Setups

Funding	German Research Foundation
Project	PAK 250 • Subproject 1
Contact	M.Sc. A. Güner • Dipl.-Ing. Q. Yin

In the second period, subproject 1 of the research group deals with the analysis and development of experimental material tests to determine subsequent yield loci for sheet materials. For this purpose, the in-plane torsion test with full and twin bridge specimen is used. Both geometries are suitable for cyclic loadings. The full geometry provides multiple different shear curves from a single specimen. The twin bridge specimen is able to obtain shear loads with superimposed normal stresses by arranging the slits at different radii. Another aim is to use an X-ray Diffractometer (XRD) for direct stress measurement on the specimen. In addition, the combination of this system with an optical measurement system for determining the complete deformation history of a material point will be realized (consisting of stress and strain components). Both systems will be utilized simultaneously, in-situ and without relief of the sample for determining the initial and subsequent yield loci.

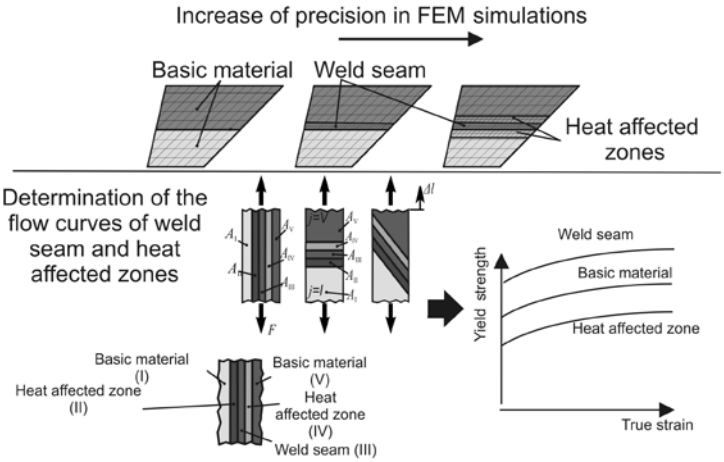


XRD measurement of stresses and cyclic in-plane torsion tests

3.3.12 Forming Properties of Laser-Welded and Tailor-Welded Blanks Made of High-Strength Muliti Phase Steels – Characterization, Modeling, Verification

Funding	FOSTA
Project	P 890
Contact	Dipl.-Ing. Th. Mennecart

The technological and economical requirements of the sheet metal production for car bodies consist of reducing the weight and simultaneously increasing the passive safety for passengers with least possible costs. One possible solution is the use of Tailor Welded Blanks made of high-strength multi-phase steels. Due to the imprecise modeling of TWB for forming simulations until now, the use of TWB in car bodies is still rare. The aim of this project, which is carried out in cooperation with Thyssen Krupp Steel Europe, is the characterization of TWB with three common steel grades and the modeling of these TWB through the elaboration of an analytical approach. In further steps the results of this method will be verified by forming demonstration car body parts and by comparing the forming results with FE simulations. The essential result of this project should be a practical and easy to apply method for carrying out FE simulations of TWB.

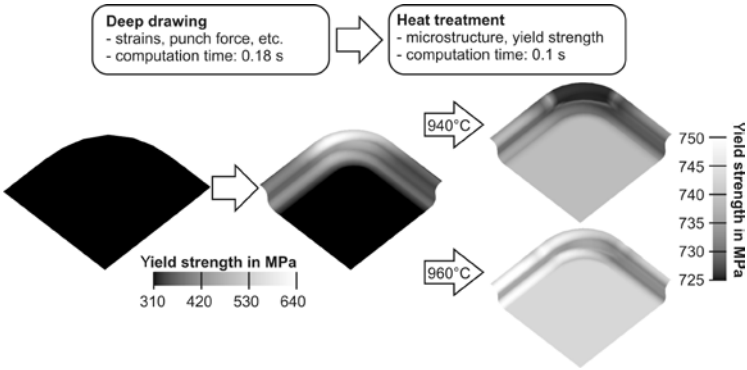


Method for characterization of TWB

3.3.13 Time Efficient Modeling and Calculation of Process Chains in Sheet Metal Forming and Processing

Funding	German Research Foundation
Project	SPP1204 • TE 508/11-2
Contact	Dipl.-Ing. T. Cwiekala

The aim of this project is the time-efficient calculation of the process chain deep drawing – cutting – heat treatment – welding for the steel type LH800.
For the calculation of deep drawing processes an analytical-based method was developed within this project, which allows the prediction of strains in the deep drawn parts. With this method it is possible to calculate the part properties as for example material strength after forming. To predict the part properties, after heat treatment as well, this method was extended to enable the calculation of microstructural properties and material strength depending on previous deformation and heat treatment. For this purpose, analysis results of LH800 were used, delivered by the Institute of Materials Science in Hannover. The figure shows the distribution of material strength in the part after deep drawing and after heat treatment.



Development of material strength during the process chain

3.4 Department of Bending Technology

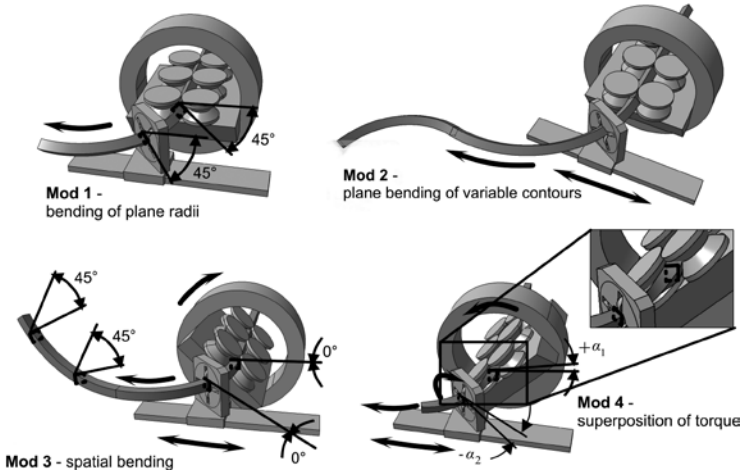
Head Dipl.-Ing. Matthias Hermes

The department of bending technology provides a large range of innovative ideas and solutions in the field of tube and sheet metal bending by process developments, process optimization, and basic research. This is done with the objective of combining basic and applied research work. Often, this work involves problems when forming modern lightweight materials like high-strength steel alloys and aluminum. The special challenges for bending machines and processes is investigated in the department and the according research projects. By this work the processes are further developed and optimized.
For example, the patented process "TSS Bending", developed for bending non-circular cross sections, was enhanced by a special inductive bending device that allows the bending of high-strength steel tubes. In a parallel running project the transfer of the knowledge about the process "TSS Bending" obtained so far is realized by the development of a marketable machine prototype in cooperation with the partner company.
Another example is the "Incremental Tube Forming" (ITF). The machine prototype is now finished and future work includes a four-year basic research project with the new machine already having industrial standard.
In the field of sheet metal bending the patented process "free bending with incremental stress superposition" is further investigated. At present, the focus is on bending of tailored blanks and high-strength steels.
The process „RoProFlex" (flexible forming of tubes and profiles) was patented last year. This year, a project is run with the aim of building up a test machine for incremental 3D forming of profiles with arbitrary cross sections over the longitudinal axis.
In the following, some details of the projects are shown.

3.4.1 3D Bending of Profiles Using Stress Superposition

Funding	German Research Foundation
Project	TE 508/15-2
Contact	Dipl.-Ing. M. Hermes

The aim of this research project was the theoretical and experimental investigation of an innovative process for 3D bending of profiles. Compared to conventional processes like stretch bending, the advantage of Torque Superposed Spatial (TSS) bending is a kinematic definition of the bending contour leading to more flexibility and cost efficiency, especially in small to medium batch production. To define the spatial geometry of the workpiece, the process can be run in four bending modi. In the first research period the focus was placed on the design of a special machine which was built and developed at the IUL. The main work of the second research period was the experimental investigation of the process to verify an analytical model and a FE process simulation. At the same time, these basic research results were used for the development of the process planning system PROFI 3D to calculate an NC code for applied workpieces. The results of this research project are currently transferred to industry by a project with a company which includes the design of an industrial machine.



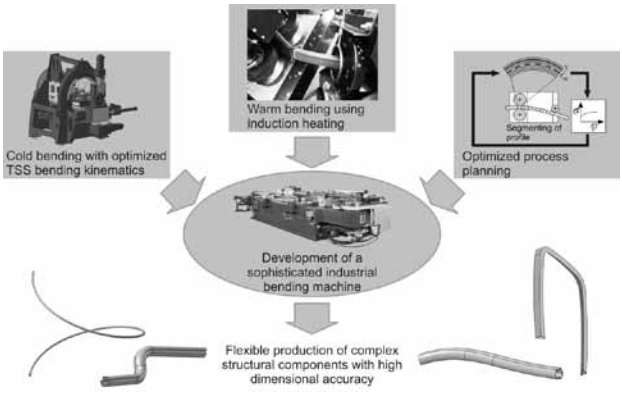
The four bending modi of the TSS machine

3.4.2 Development of a Bending Machine for the Production of Three-Dimensionally Shaped Complex Parts made of Profile Material

Funding	BMWi/ZIM-KF
Project	KF2198115LK1
Contact	Dipl.-Ing. M. Hermes

A new manufacturing and machine technology for flexible cold and warm bending of profiles with complex cross sections to three-dimensional structures will be developed in cooperation with Schwarze-Robitec GmbH. The design will be done on the basis of the Torque Superposed Spatial bending process (TSS bending), which was developed at the IUL.
The process to be designed shall take the high standards needed for the processing of profiles, especially concerning the dimensional accuracy and shape tolerance into account. The focus is put on flexibility in the definition of the bending contour, which can only be realized by a kinematic production of the desired shape. In the course of the project two main goals shall be achieved:

- Development and design of a powerful specialized machine for TSS bending
- Investigations of the specific properties of the TSS bending process and machine with the aim of producing a fundamental and industrially applicable process control

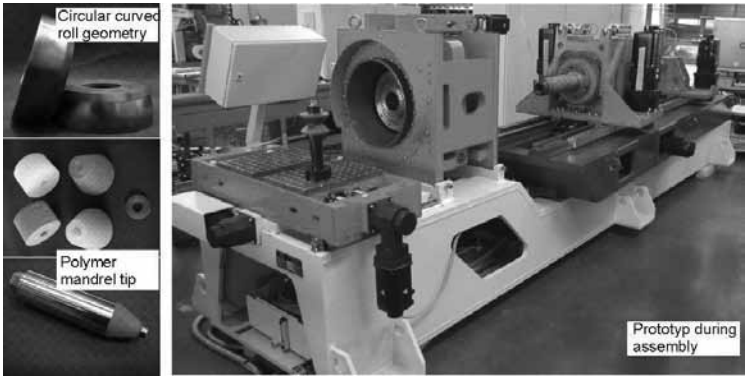


Aim of the cooperative project

3.4.3 Investigation and Development of a Process and a Machine Technology for Incremental Tube Forming

Funding	BMWi/ZIM-KF
Project	KF2198101LK9
Contact	Dipl.-Ing. M. Hermes

The aim of this project is the investigation and development of a manufacturing process and a machine technology for Incremental Tube Forming (ITF). This project is carried out in cooperation with transfluid® Maschinenbau GmbH, Schmallenberg. The incremental tube forming process enables the manufacture of bent tubes with varying cross sections along the longitudinal axis. ITF is a process combination of two processes: Spinning, which is used for reducing the diameter of the tube, and freeform bending, which enables the production of three-dimensional bent tubes.
The focus of current activities is on the completion of the prototype as well as the development and optimization of tool concepts. Beside conventional tools made of steel, the usage of polymer tools is examined. After the start-up of the new machine, further work will concentrate on a deeper examination of the process limits and a possible transfer to industrial applications.

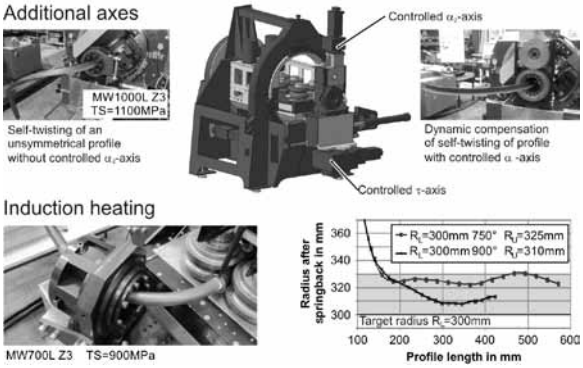


Optimization of tool concepts and realized machine setup

3.4.4 ProTuBend – Flexible and Cost-Effective Innovative Manufacturing of Complex 3D-Bent Tubes and Profiles Made of High-Strength Steels for Automotive Lightweight Structures

Funding	EU, RFCS
Project	RFSR-CT-2009-00017
Contact	Dipl.-Ing. D. Staupendahl • Dipl.-Ing. Ch. Becker

Lightweight structures in the automotive and utility vehicle industry can only be produced by adapting production processes for the processing of high-strength materials. The aim of the ProTuBend project is to advance the Torque Superposed Spatial (TSS) bending process and Incremental Tube Forming (ITF) for the industrial use so as to becapable of forming and bending load-optimized 3D tubes and profiles made of high and ultrahigh-strength steel.
In current investigations the process limits and possible process extensions of the two processes are analyzed using high-strength air hardening steel (MW700L and MW1000L from SMP) and dual phase steel (DP800, DP1000 from SSAB).
Through the extension of the bending head of the TSS bending kinematics by two controlled axes the self-torsion of unsymmetrical profiles can be prevented. The use of induction heating during bending results in a significant bending radius and springback reduction. In further investigations the effect of the heating process on the material properties will be analyzed and the process stability of the extended process will be optimized.

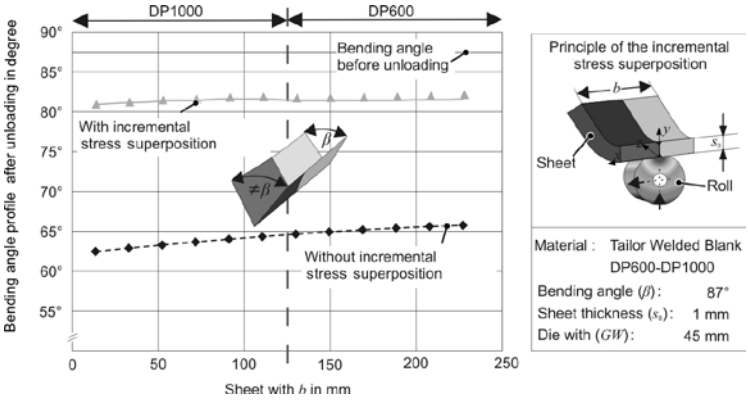


Process extension of the TSS bending process

3.4.5 Investigation of Springback Compensation in Sheet Metal Bending Processes by Incremental Compressive Stress Superposition

Funding	German Research Foundation
Project	MA1883
Contact	Dipl.-Ing. A. Weinrich

The demand for lightweight structures with the aim of at reducing energy consumption is rising continuously. The production of bent tailored blanks is as a good alternative in this context. However, the inhomogeneous springback of tailored blanks as a consequence of the different material properties is a major challenge for industrial use.
To obtain homogeneous bending angle profile along the sheet width, a new method developed at the IUL, based on the incremental stress superposition, can be used. As a result of the stress superposition the corresponding forming zone is completely plasticized so that only elastic springback remains at the thighs.
When using the incremental stress superposition method on tailor welded blanks (DP600 and DP1000), both a significant reduction of the springback and a uniform bending angle profile could be achieved. An improvement of the final quality could be achieved and an industrial application without extensive reworking is possible.

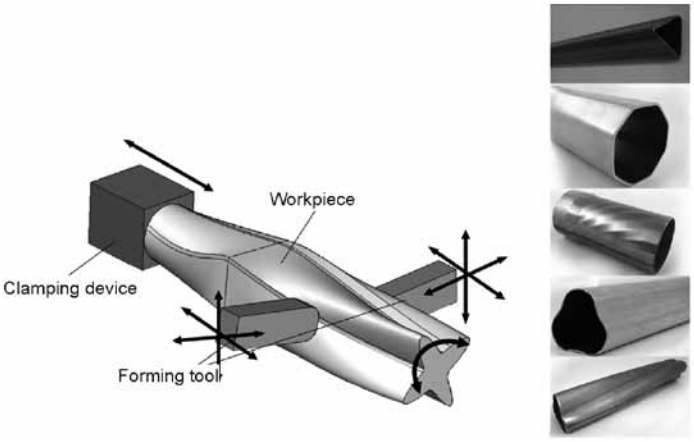


Bending angle profile of bended tailor welded blanks using Incremental stress superposition in bending

3.4.6 Flexible Production of Lightweight Structures by Innovative Forming Technologies

Funding	NRW.BANK
Project	w1006sb017a
Contact	Dipl.-Ing. M. Hermes • Dipl.-Ing. Ch. Becker

At the Institute of Forming Technology and Lightweight Construction (IUL) a new process for the flexible manufacturing of tubes and profiles called RoProFlex was developed. With the RoProFlex process the cross section of tubes and profiles can be formed freely along the longitudinal axis with a CNC control to almost any desired cross section of the workpiece. Because of the possible variation of geometries the process has a wide scope of application. Starting with lightweight parts for cars and utility vehicles, continuing with ultra light precision parts like gears or screw rotors, and also considering for instance medical implants, a manufacturing is basically possible.
In this project the scientific knowledge about the process should be transferred to a market-ready application in the industry. The three main aspects of the project are the development of a numerically controlled machine, the further development of the process as well as the development of a CAD/CAM-based process planning tool.

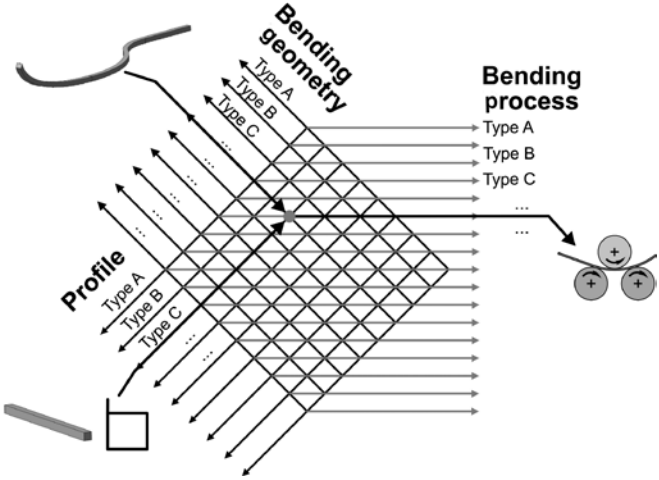


Principle of the process RoProFlex

3.4.7 Standardization of Bending Tubes and Profiles

Funding	Federal Ministry of Economics and Technology
Project	01FS11019
Contact	Dipl.-Ing. M. Hermes • Dipl.-Ing. Ch. Becker M.Sc. M.Eng. Ch. Pleul

Within this joint research project, Tracto-Technik GmbH & Co. KG, Universität Siegen, and Technische Universität Dortmund will realize an industrial standard for profile and tube bending for the first time. Focus at the IUL is the field of bending of profiles with non-circular cross sections. The aim of IUL´s project is to develop the standard and and process planning tool for this technology. The first step is an investigation of standards that are already common for those workpieces or are relevant for them. In the following steps IUL will define bending quality standards by measuring a representative spectrum of bent parts. Finally, this information will be included in the new standard and a planning matrix based on a database will be developed. The project results will be available for the industry.

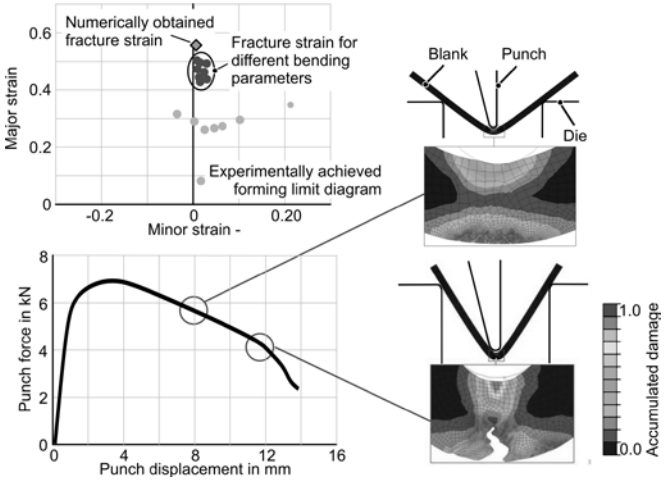


Decision matrix for planning profile bending processes

3.4.8 Damage Analysis and Prediction in Bending Processes

Funding	German Research Foundation
Project	TE 508-21-1
Contact	M.Sc. M. Malekipour Gharbi
Status	Completed

The main objective of this project was to develop a reliable damage model, based on continuum damage mechanics which can be used in bending processes. This model should be able to predict where and when the damage occurs. To reach this objective, experimental-numerical investigations have been performed.
In experimental terms, different experiments for the identification of plasticity and damage parameters are carried out using enhanced measurement techniques to record the local and global fields.
The numerical approach is based on fully coupled constitutive equations accounting for mixed non-linear isotropic and kinematic hardening, strongly coupled with isotropic ductile damage. Plasticity and damage have been treated isotropically.
Based on the experimental tensile test, the plasticity and damage parameters have been identified. The bending process has been modeled and simulated. Simulations have shown promising results which can be quantitatively and qualitatively compared to experiments.



Damage accumulation during bending process

3.5 Department of Non-Conventional Processes

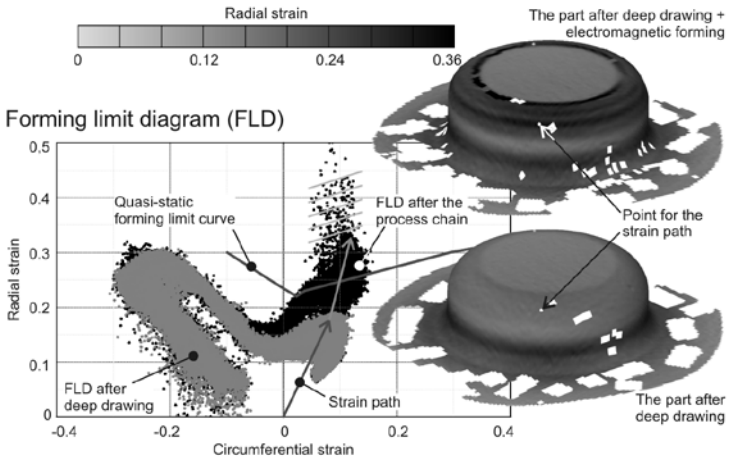
Head Dipl.-Ing. Lukas Kwiatkowski

The scientific team of the department “Non-conventional processes” considers especially atypical forming processes. Currently, main topics are incremental forming, electromagnetic forming, and joining by forming. The objective is to provide attractive alternatives to already established systems or to develop specialized techniques for niches within the production technology which could not yet be handled properly through conventional technologies. In all projects the investigations are oriented towards understanding the basics and delivering the fundamental knowledge.
In the research field of sheet metal forming the advantages of both processes, electromagnetic forming and conventional forming using a press, could be combined beneficially. Already known forming limits could be overcome impressively by this combination. Beyond fluid-based technologies electromagnetic forming is also used for joining. One objective is to establish a process window for the so called “impact welding”. In incremental forming investigations about the cold formability of plastics are conducted. Using an especially developed material model, laboratory as well as numerical experiments can be performed. To allow a structured and efficient analysis of the large number of parameters during incremental forming of metals, a well established collaboration with the department of statistics can be benefited from. Apart from this, the feasibility of incremental bulk forming operations applied to sheet metal is being investigated. Here, the focus is on the understanding of the three-dimensional material flow. Main objective is the manufacturing of optimized components in terms of functionality and weight. The investigations of incremental processes are completed by a process development for a post treatment of coated tools for deep drawing by roller burnishing.

3.5.1 Process Development for Combined Conventional and Electromagnetic Forming Operations

Funding	German Research Foundation
Project	PAK 343 • Subproject 1
Contact	M.Sc. O. K. Demir

In this research project a methodology is being developed to design process chains composed of quasi-static and dynamic, especially electromagnetic forming processes. Two sample process chains, deep drawing with subsequent electromagnetic forming and electromagnetic tube compression with hydraulic forming, are investigated.
As an outcome of the first funding period, the conventional forming limits could be extended by means of combinations of strain path and strain rate changes. The effects of these combinations on the process window were experimentally and numerically investigated. The continuation of the project is currently being planned. The research is being carried out in collaboration with the Chair for Theory of Electrical Engineering and Computational Electromagnetics (Hamburg), the Institute of Applied Mechanics (Aachen), and the Institute of Materials Science (Hannover).

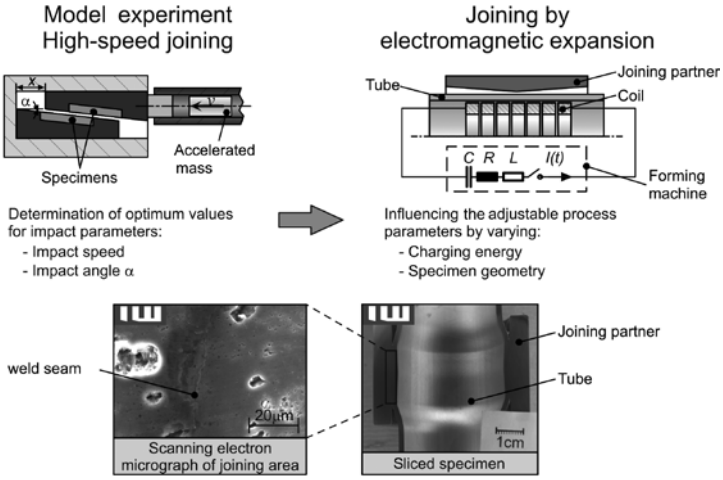


Exceeding the quasi-static forming limits with the process chain

3.5.2 Investigation of the Complex Interdependencies in Electromagnetic Tube Forming

Funding	German Research Foundation
Project	TE 508/19-1
Contact	Dipl.-Wirt.-Ing. S. Gies

In cooperation with the institute of Materials Science (IW) of the Leibniz Universität Hannover strategies for process control and joint design of impact welded joints produced by electromagnetic forming are developed. The subproject carried located at the IW deals with the identification of beneficial impact parameter values using a high-speed joining model experiment. By collision of two sheet metal specimens with varying impact speed and impact angle an impact welded joint is created which is analyzed in a subsequent step. These investigations revealed that there is an optimum value for the impact velocity which depends on the materials to be joined.Based on these results, the influence of the adjustable process parameters, e.g. charging energy, discharge current, or tool coil geometry, on the deformation behavior of the joining partners is analyzed at the IUL, so that the impact parameters during the joining process match with the optimum values identified in the model experiment.

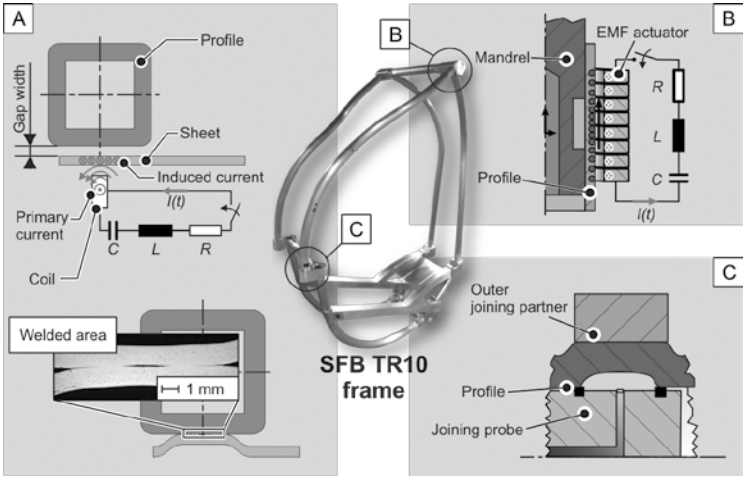


Strategy for the process design of impact welding by electromagnetic forming

3.5.3 Joining by Forming

Funding	German Research Foundation
Project	SFB/TR 10 • Subproject A10
Contact	Dipl.-Wirt.-Ing. Ch. Weddeling

Within the subproject A10 alternative joining strategies for the flexible manufacturing of lightweight frame structures are developed. In the current period the focus of the project lies on adhesive sheet-to-profile-connections manufactured by magnetic impulse welding (MIW), which is a process variant of electromagnetic forming (EMF). The goals of the subproject are the development of general principles for the process design and joining zone design as well as the development of advanced tool coils. As basis for these tasks, fundamental technological investigations and numerical analyses are performed.
Furthermore interference-fit and form-fit profile-to-profile connections manufactured by joining by hydroforming and by EMF are investigated within the project. For these connection types special analytical models for the process design and joining zone design are developed. Therefore, technological investigations and numerical analyses are performed as well.

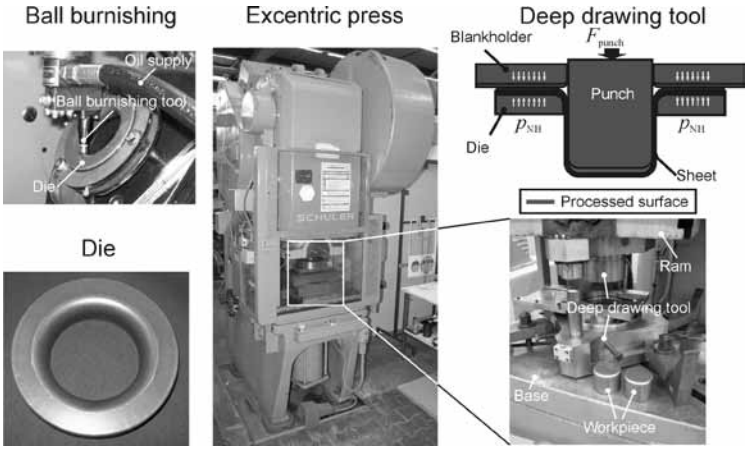


a) Magnetic impulse welding, b) Joining by electromagnetic forming, c) Joining by hydroforming

3.5.4 Tribological Investigation of Burnished, Thermally Sprayed Tool Surfaces

Funding	German Research Foundation
Project	SFB 708 • Subproject A3
Contact	M.Sc. V. Franzen

In this research project the performance characteristics of thermally sprayed, wear-resistant coatings for deep drawing tools are investigated. The surface topography of the effective coated tool surface is adjusted by incremental ball burnishing.
Baseline investigations on roller burnishing of thermally sprayed surfaces were conducted in in the first funding period, which ended in 2010. At the beginning of the second funding period, a deep drawing wear testing set-up was developed. Based on the gained knowledge about the wear resistance and frictional behavior of the thermally sprayed coatings in the tribo-system, consisting of hard material coating, lubricant, and sheet, new approaches for the process strategies in deep drawing of high strength steel sheets can be developed. It is planned to adjust the frictional behavior of the effective tool surface by suitable roller burnishing strategies and local texturing in order to optimize the sheet material flow during deep drawing.

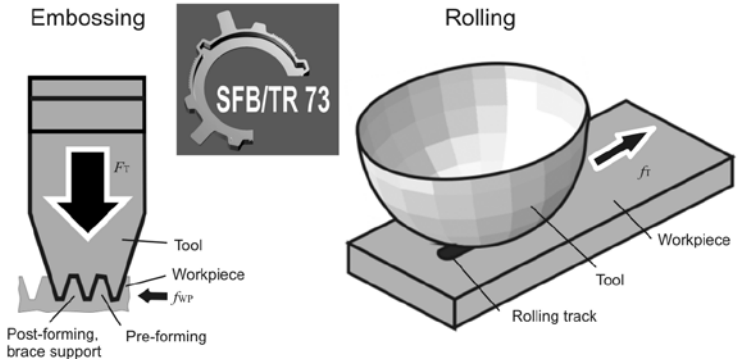


Tribological analysis of burnished, coated deep drawing tools

3.5.5 Fundamental Research and Process Development for Manufacturing of Load-Optimized Parts by Incremental Forming of Thick Metal Sheets

Funding	German Research Foundation
Project	SFB/TR 73 • Subproject A4
Contact	Dipl.-Ing. P. Sieczkarek

In this project the focus is on the development of appropriate manufacturing routes for near net shape and load-optimized parts made of sheet metal by applying bulk forming processes. The outstanding feature is the composition of different and locally restricted forming sequences. The material is distributed first and then calibrated in a final forming step.
Within the scope of the investigation of incremental rolling a process window could be established which allows a defined adjustment of the material flow, of the amount of local straining, and the material hardness. The use of an appropriate process strategy allows the manufacturing of components which are identical in geometry but different in their local mechanical properties.
In the next step the studies will be accomplished by the utilization of a new, specialized incremental forming machine. The project is implemented in a transregional collaboration between the universities of Erlangen and Hannover (Transregio 73).

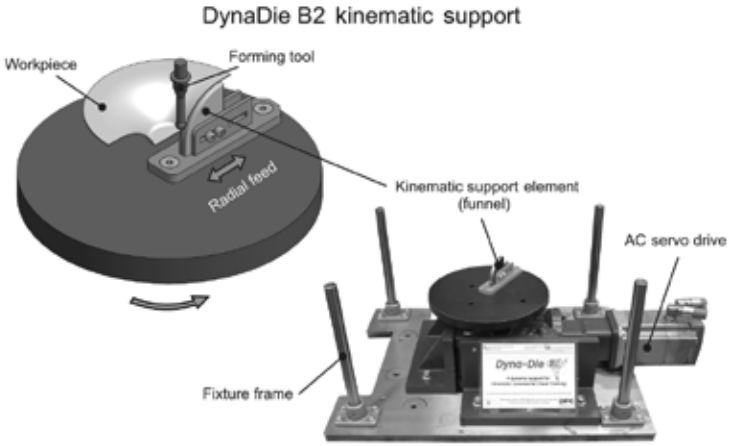


Forming sequences in incremental sheet-bulk metal forming

3.5.6 Characterization of the Dynamical Process Parameters of Incremental Sheet Metal Forming (ISF)

Funding	German Research Foundation
Project	SFB 823 • Subproject B2
Contact	Dipl.-Ing. (FH) G. Sebastiani M.Sc.

The present project is dedicated to finding an analytical description of the cause-effect-principles in ISF. The work focuses on a dynamic change of the process parameters (factors) during forming.
Using statistically designed experimental batches featuring fixed settings, the main-factor with effects on accuracy, thinning, and surface quality have been identified. Based on these results, the current investigations extend the factors to the dynamic domain, using an upgraded version of the kinematic support DynaDie B2. This tool has been developed to analyze the influence of bending-under-tension and contact stress components on the formability. Having identified a process window in the kinematic settings, a dynamic change of the support strategies will be considered next.
Contributing to the Collaborative Research Center 823, project B2 provides a technological application to the theoretical projects while relying on novel developments in mathematical and statistical data analysis.

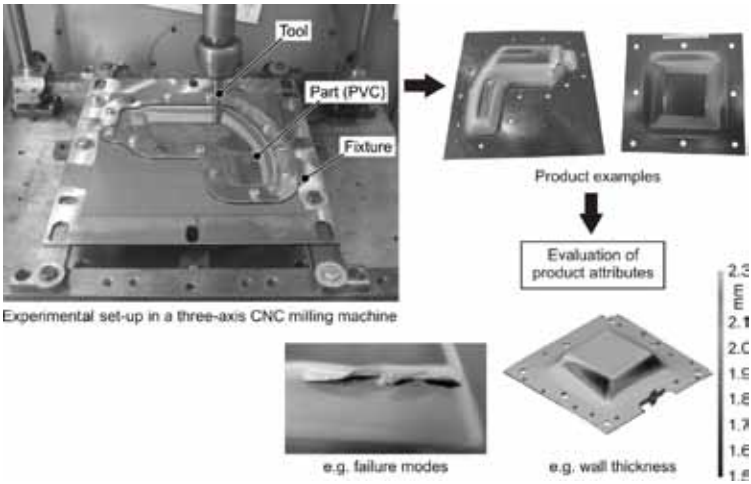


Developed kinematic support DynaDie B2

3.5.7 Investigation of the Deformation Behavior of Thermoplastics during Incremental Cold Forming

Funding	German Research Foundation
Project	TE 508/20-1
Contact	Dipl.-Ing. L. Kwiatkowski

Current methods for the production of thermoplastic parts, such as injection moulding, are not economical for prototyping and small patch production due to the part-dependent tooling and, hence, high capital investments for equipment. In contrast, preliminary tests have shown that thermoplastic sheets can be formed by the flexible incremental sheet forming process. The aim of this project is the fundamental-based incremental design of thermoplastics, so that forming potentials can be utilized as far as possible by an adequate process design. For this purpose, statistically designed series of tests are carried out to obtain knowledge about the influence of various process parameters, such as tool diameter and vertical infeed, on the part properties. Subsequently, a process window for manufacturing trouble-free components is deduced.

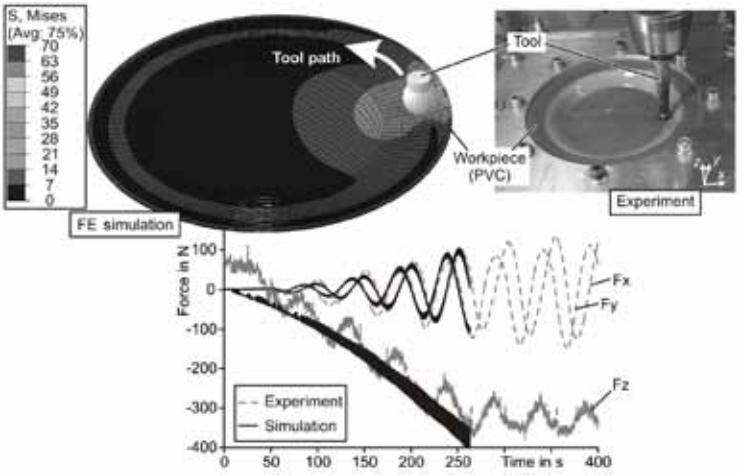


Investigation of the properties of incrementally formed parts after varying the process parameters

3.5.8 Creation of a Material Model for Numerical Investigations on Forming of Laminar Thermoplastic Polymers

Funding	Graduate School of Energy Efficient Production and Logistics
Contact	Dipl.-Ing. S. Alkas Yonan

Thermoplastic polymers can be formed at room temperature, as earlier incremental sheet forming tests have shown. The aim of this project is to characterize the deformation behaviour of thermoplastics at room temperature and to analyse the mechanical properties of cold-formed parts. Different sheet forming processes will be investigated numerically and experimentally.
For the numerical investigation of cold forming of thermoplastics a visco-plastic material model, based on the results of material characterization tests, is formulated and implemented in an FEM solver. The identification of material parameters is performed for three thermoplastics, PVC, HDPE, and PC. Subsequently, this material model is verified with three-dimensional simulations. For this purpose, cold-formed parts are produced and compared with the simulation results.



Verification of the material model for incremental cold forming by comparing the forming forces between FE simulation and experiment

3.6 Department of Applied Mechanics in Forming Technologies

Head Celal Soyarslan, PhD

Current trends in metal forming processes involve forming of lightweight components by increasing the variability of these products, taking into account the energy efficiency in production, process control, shortening, flexibilization, and integration of versatile processes. Furthermore, the prediction of the product quality and control of microstructure evolution is a challenging task that forming technology is faced with. Thus, the utilization of analytical and numerical tools to optimize existing methods or to develop new methods of manufacturing within this area is inevitable.

The aim of department of Applied Mechanics in Forming Technologies (AMFT) is to bridge this gap by elaborating analytical and numerical methods based on the state of the art improvements in literature for process analysis and design. Expected outcomes are twofold: a thorough understanding of the underlying physical mechanisms and the implementation of this know-how for technological enhancements, especially the ones using newly developed material classes.

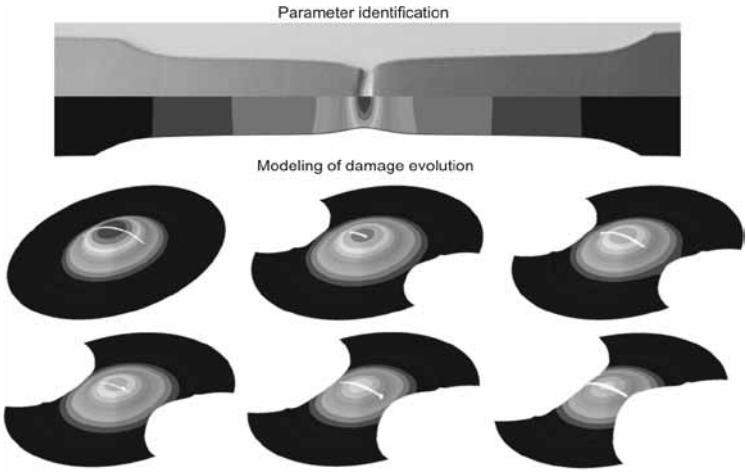
The department's current research fields mainly concentrate on modeling and prediction of deformation, damage and consequent failure in bulk, sheet and sheet-bulk forming processes involving the development of direct and inverse methodologies for material characterization, aiming at minimized experimental burden. For this purpose, state of the art micromechanical and phenomenological material modeling approaches are dealt with. For the cases where analytical approaches fall short, numerical solutions are made available by developing user-defined material subroutines for leading finite element software with solid and thin shell formulations for bulk and sheet metal forming simulations, respectively. These models give account for finite strain formulations, various combined isotropic-kinematic hardening regimes (e.g. Prager-Ziegler, Armstrong Frederic, Yoshida Uemori, etc.), various inherent anisotropies (e.g. Hill family, Barlat family, etc.), various (normal, shear, and mixed) fracture criteria (deformation uncoupled) (CrachFEM, MMC, uncoupled Lemaitre, etc.), and micromechanically or phenomenologically based (deformation coupled) damage models (Lemaitre, Gurson, etc.).

Since its foundation in April 2011, the department works intensively on these fields to meet the mentioned requirements in close collaboration with other departments of sheet forming, bulk forming, bending, and non-conventional forming.

3.6.1 Development of an Industry-Oriented Failure Model for Sheet Metal Forming Simulations of Advanced High Strength Steels (AHSS)

Funding	FOSTA
Project	P 853
Contact	M.Sc. K. Isik • PhD C. Soyarslan

Despite their wide application in sheet metal forming analysis, forming limit diagrams cannot supply reliable results for the cases involving non-proportional strain paths or material classes with reduced ductility such as advanced high-strength steels. In the present study, a continuum damage model (Lemaitre model) is investigated in order to remedy the existing incapability in failure prediction for these materials.
The project aims at providing a methodology for failure prediction in advanced high-strength steels, including the material characterization phase which involves a range of stress triaxiality ratios, i.e. tensile tests (with notched specimens), in-plane shear and Nakazima tests. For a validation of the methodology, deep drawing tests with several geometries will be conducted.

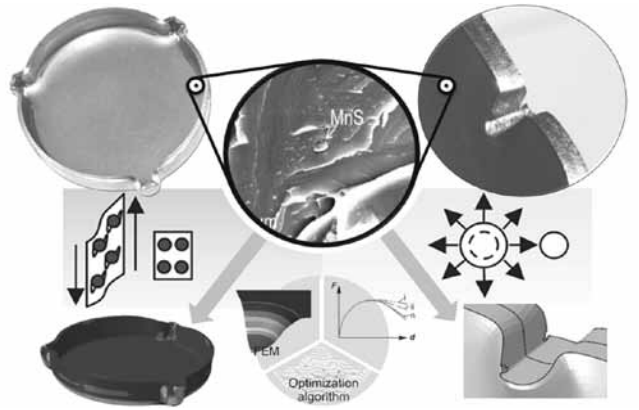


Validation studies with Nakazima specimens

3.6.2 Analysis of Load History-Dependent Evolution of Damage and Microstructure for the Numerical Design of Sheet-Bulk Metal Forming Processes

Funding	German Research Foundation
Project	SFB/TR 73 • Subproject C4
Contact	M.Sc. K. Isik • PhD C. Soyarslan

The application of conventional bulk forming operations on sheet blanks introduces an alternative forming approach for complex-shaped products. A combined experimental and numerical investigation of microstructure development in the context of voidage during sheet-bulk metal forming is aimed at. Experimental studies cover mechanical material characterization and validation as well as post mortem surface inspections where the void-driven destabilizing mechanisms leading to material fracture are being investigated. Numerical studies involve the implementation and improvement of existing physically-based, advanced damage theories, which give account for normal as well as shear stress state dominated material deterioration, into finite element framework with non-local extensions. A database, which includes the quantitative formability limits in bulk-sheet forming processes to assist the selection of the materials and design improvement in current applications, will also be developed.



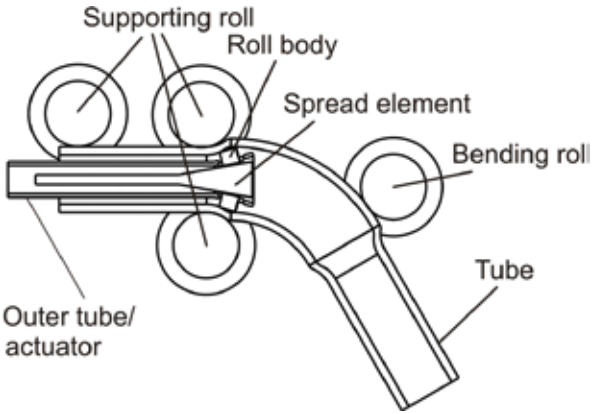
Mechanisms and effects of ductile damage

3.7 Patents

3.7.1 Device and Process Principle for the Bending of Closed Tubes

Patentholder	Technische Universität Dortmund
Status	Filed
Inventors	Dipl.-Ing. A. Selvaggio Dipl.-Ing. M. Hermes Prof. Dr.-Ing. A. E. Tekkaya

As a part of the invention a mandrel was developed(see figure), working in a similar way as an inside roller. The mandrel has a rotary drive and radially adjustable rolls, which can be adjusted within the bending process to produce tubes with various diameters. The inner diameter of tubes is widened by a rotating roll process that also plasticizes the material in the forming zone of the bending process. Because of the plasticized material the elastic residual stress component and, thus, the springback is reduced, which is an elementary problem during the use of high-strength materials. Additionally, a reduction of the cross sectional deformation like ovality, wrinkles in the pressure zone, or a reduction of the wall thickness in the tension zone can be achieved by using this device. Finally, the developed device can also be used for the production of curved tailored tubes in only one step or for the bending of tailored tubes.

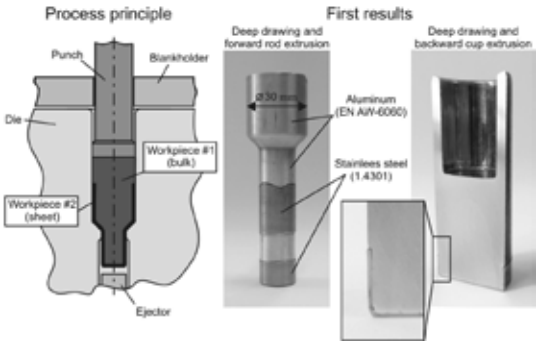


Schematic view of the invented device

3.7.2 Process for the Manufacturing of Composite Metal Structures by Combined Deep Drawing and Cold Forging

Application number	PCT/DE2011/001053
Patentholder	Technische Universität Dortmund
Status	Filed
Inventors	Dipl.-Ing. A. Jäger Dipl.-Ing. S. Hänisch B.Eng. S. Bröckerhoff Prof. Dr.-Ing. A. E. Tekkaya

The invention concerns a process combination consisting of deep drawing and cold forging for the manufacturing of composite metal structures made of a sheet metal and a bulk metal components. Initially, by substituting the deep drawing mandrel by a cylindrical bulk metal workpiece, the sheet is deep drawn into the shape of a cup which then partly covers the bulk component. With increasing stroke the bulk metal workpiece starts to be cold forged, while the sheet component is additionally formed or even calibrated. As a result, composite metal structures with bulk material in the core partly covered with a sheet material can be produced. Examples of application are lightweight parts with a wear-resistant surface or products with different heat conductivity between the core and the sleeve.

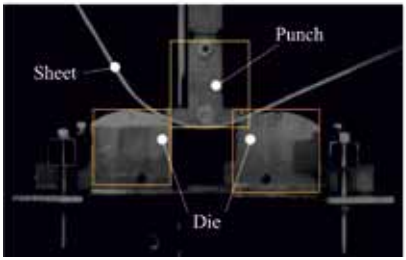


Combined deep drawing and cold forging

3.7.3 Strategy for Incremental Forming of Sheets, Especially for Forming of Tubes

Application number	PCT /DE/2011/000015
Patentholder	Technische Universität Dortmund
Status	Filed
Inventors	Jun.-Prof. Dr.-Ing. A. Brosius Dipl.-Inform. A. Selvaggio Dr.-Ing. U. Dirksen Prof. Dr.-Ing. A. E. Tekkaya

The manufacturing of large and thick-walled tubes by incremental air bending (e.g. JCO process) without control strategies is highly complex. Due to disturbances like material property variation, springback, and a generally different hardening behaviour, the problem is being approached by using modern materials like high-strength steels. Furthermore, a detailed analysis of this process is quite expensive because of large part dimensions. Therefore, the production quality strongly depends on operating personal.
Because of these drawbacks this invention will help to realize an automated manufacturing process of incremental tube production with sequential adjustment control. It will be a technological add-on to the mentioned JCO process, consisting of an adjustment and an online-measuring method.



$$r(\mathbf{a},\mathbf{b}) = \frac{\sum_{i=1}^{n}(a_i-\bar{a})(b_i-\bar{b})}{\sqrt{\sum_{i=1}^{n}(a_i-\bar{a})^2}\cdot\sqrt{\sum_{i=1}^{n}(b_i-\bar{b})^2}} = \frac{\sum_{i=1}^{n}a_ib_i-\frac{1}{n}\sum_{i=1}^{n}a_i\sum_{i=1}^{n}b_i}{\sqrt{\sum_{i=1}^{n}a_i^2-\frac{1}{n}\left(\sum_{i=1}^{n}a_i\right)^2}\cdot\sqrt{\sum_{i=1}^{n}b_i^2-\frac{1}{n}\left(\sum_{i=1}^{n}b_i\right)^2}}$$

Automated detection of sheet contour

3.8 Cooperations

At this point we would like to express our gratitude to the large number of various cooperation partners in 2011 which have added to our joint success.

University cooperations

University cooperations at national level

- Fachgebiet Fluidtechnik, Technische Universität Dortmund
- 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 mathematische Statistik und naturwissenschaftliche Anwendungen, Technische Universität Dortmund
- Lehrstuhl für Werkstofftechnologie, Technische Universität Dortmund
- Lehrstuhl für Wissenschaftliches Rechnen, Technische Universität Dortmund
- Center for Continuing Education, Technische Universität Dortmund

- Arbeitsbereich Produktions- und Fertigungstechnik, Technische Universität Hamburg-Harburg
- Fachbereich Produktionstechnik, Universität Bremen
- Fraunhofer-Institut für Solare Energiesysteme ISE, Freiburg
- Fraunhofer-Institut für Werkzeugmaschinen und Umformtechnik, Technische Universität Chemnitz
- 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 Konstruktions- und Fertigungstechnik, Universität der Bundeswehr, Hamburg
- Institut für Massivbau, Technische Universität Dresden
- Institut für Metallformung, Technische Universität Bergakademie Freiberg
- Institut für Metallurgie, Abteilung Werkstoffumformung, Technische Universität Clausthal-Zellerfeld
- Institut für Produktionstechnik und Logistik, Universität Kassel
- Institut für Produktionstechnik und Umformmaschinen, Technische Universität Darmstadt
- Institut für Umformtechnik und Umformmaschinen, Leibniz Universität Hannover
- Institut für Umformtechnik und Umformmaschinen, Universität Stuttgart
- Institut für Umformtechnik, Universität Siegen
- Institut für Werkstoffkunde I, Karlsruher Institut für Technologie (KIT)
- Institut für Werkstoffkunde, Leibniz Universität Hannover
- Institut für Werkstoffwissenschaft und Werkstofftechnik, Professur Oberflächentechnik/Funktionswerkstoffe, Technische Universität Chemnitz
- Institut für Werkzeugmaschinen und Betriebswissenschaften, Technische Universität München
- Labor für Fahrwerktechnik, Hochschule Osnabrück
- Lehrstuhl für Fertigungstechnik und Werkzeugmaschinen, Universität Siegen
- Lehrstuhl für Fertigungstechnologie, Friedrich-Alexander-Universität Erlangen-Nürnberg
- 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 Werkstoffkunde, Universität Paderborn

- Lehrstuhl für Werkstofftechnik, Universität Rostock
- Materialprüfungsanstalt, Universität Stuttgart
- 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

University cooperations at international level

- Abdelmalek Essaâdi University (UAE), (Martil) Tetuon-Tanger, Morocco
- Center of Manufacturing and Industrial Management (CMIM), Universidade Técnica de Lisboa, Portugal
- Charles Delaunay Institute, Labarotoire des Systèmes Mécanique-set d'ingénierie Simultanée (LASMIS), Université de Technologie deTroyes, France
- Department of Industrial Engineering, Università degli Studi di Palermo, Italy
- Department of Mechanical Engineering, Northwestern University, Evanston, IL, USA
- 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, National Cheng Kung University, Tainan, Taiwan, Republic of China
- Department of Mechanical Engineering, Tsinghua University, Beijing, China
- Department of Mechanical Engineering, Università della Calabria, Rende (CS), Italy
- Department of Mechanical Engineering and Materials Science Program, University of New Hampshire, NH, USA

- DIEM-Tech Manufacturing Technology Group, Università di Bologna, Italy
- Ecole nationale Supérieure d'Arts et Métiers (ENSAM), ParisTech, Paris, France
- Faculty of Engineering Technology, Universiteit Twente, The Netherlands
- Forming Laboratory, Faculty of Mechanical Engineering, University of Ljubljana, Ljubljana, Slovenia
- Institute for Manufacturing, Department of Engineering, University of Cambridge, Great Britain
- 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
- Metal Forming Center of Excellence, Atilim Universitesi, Ankara, Turkey
- Nagoya University, Nagoya, Japan
- Politechnika Warszawska, Warsaw, Poland
- Royal Institute of Technology KTH, Department of Production Engineering, Stockholm, Sweden
- School of Materials Science & Engineering and the Department of Plasticity Forming Engineering, Shanghai Jiao Tong University, China
- Università degli Studi di Milano - Bicocca, Mailand, Milan, Italy
- Universitatea Babeş-Bolyai, Cluj-Napoca, Romania
- Université Hassan II Mohammedia (UH2M), Casablanca, Morocco
- University of Badji Mokhtar Annaba (UBMA), Annaba, Algeria
- University of Monastir, National Engineering School of Monastir (ENIM), Monastir, Tunisia
- University of Sciences and Technology Houari Boumediene (USTHB), Algiers, Algeria
- University of Sousse, National School of Engineers (ENISo), Sousse, Tunisia

Industrial cooperations at national and international level

- Airbus S. A. S.
- Aleris Aluminum Duffel BVBA
- Alu Menziken AG, Schweiz
- alutec Metallwaren GmbH & Co. KG
- ARBURG GmbH + Co KG
- ASCAMM Technology Centre
- ASERM – Asociación Española de Rapid Manufacturing
- AUDI AG
- Auerhammer Metallwerk GmbH
- Benteler AG
- BMW AG
- borit Leichtbau-Technik GmbH
- BRUDERER AG
- Carl Bechem GmbH
- Constellium CRV (Centre de Recherches de Voreppe)
- Corus Strip Products, England
- CRF – Centro Ricerche Fiat S.C.p.A.
- Daimler AG
- Data M Sheet Metal Solutions GmbH
- DYNAmore GmbH
- Erbslöh Aktiengesellschaft
- EvoBus GmbH
- F.W. Brökelmann Aluminiumwerk GmbH & Co. KG
- Faurecia Autositze GmbH
- Forschungsvereinigung Stahlanwendung e. V.
- Franz Pauli GmbH & Co. KG
- Hirschvogel Umformtechnik GmbH
- Honsel AG
- Hydro Aluminium Deutschland GmbH
- imk automotive GmbH
- Inspire AG - IRPD

- JFE Steel Corporation, Japan
- Johnson Controls Hilchenbach GmbH
- Kirchhoff Automotive GmbH
- Kistler-Igel GmbH
- Koda Stanz- und Biegetechnik GmbH
- Kunststoff-Institut Lüdenscheid GmbH
- Kunze GmbH
- LEIBER Group GmbH & Co. KG
- MUBEA Unternehmensgruppe
- Novelis Technology AG
- Otto Fuchs KG
- Physica Ltd.
- Poynting GmbH
- Rehau AG + Co
- Repkon, Istanbul, Turkey
- Robert Bosch GmbH
- S+C Extrusion Tooling Solutions GmbH
- Salzgitter Mannesmann Forschung GmbH
- Salzgitter Mannesmann Präzisrohr GmbH
- Schnupp GmbH & Co. KG
- Schondelmaier GmbH
- Schuler AG
- Schwarze-Robitec GmbH
- Siemens Aktiengesellschaft
- Simufact Engineering GmbH
- SMS Meer GmbH
- Société Tuniesienne des filtres (MISFAT), Jedeida, Tunesia
- SSAB Swedish Steel GmbH
- SSAB Tunnplåt AB, Schweden
- Tata Steel (former Corus Technology BV)
- TECOS – Slovenian Tool and Die Development Centre
- ThyssenKrupp Presta AG
- ThyssenKrupp Steel Europe AG

- TRACTO-TECHNIK GmbH & Co. KG Spezialmaschinen
- Transfluid Maschinenbau GmbH
- TRUMPF Werkzeugmaschinen GmbH + Co. KG
- Viessmann Werke GmbH & Co. KG
- voestalpine AG
- VOLKSWAGEN AG
- Vossloh AG
- Welser Profile GmbH
- WF Maschinenbau und Blechformtechnik GmbH & Co. KG
- Wilke Werkzeugbau GmbH & Co. KG
- WILO SE
- Winkelmann Dynaform Technik GmbH & Co. KG
- ZWEZ-Chemie GmbH

Associations

- acatech – Deutsche Akademie der Technikwissenschaften
- AGU – Arbeitsgemeinschaft Umformtechnik
- AIST – Association for Iron and Steel Technology
- ASM International N.V.
- CAE – Chinese Academy of Engineering
- CIRP – The International Academy for Production Engineering
- DGM – Deutsche Gesellschaft für Materialkunde e. V.
- Europäische Forschungsgesellschaft für Blechverarbeitung e. V.
- FOSTA – Forschungsvereinigung Stahlanwendung e. V.
- GCFG – German Cold Forging Group
- GDA – Gesamtverband der Aluminiumindustrie e. V.
- I2FG – International Impulse Forming Group e. V.
- IBU – Industrieverband Blechumformung
- ICFG – International Cold Forging Group
- IDDRG – International Deep Drawing Research Group
- IMU – Industrieverband Massivumformung
- JSTP - The Japan Society for Technology of Plasticity
- KIST – Kompetenz- und Innovationszentrum für die Stanz Technologie e. V.

- Stahlinstitut VDEh
- VDI – Verein Deutscher Ingenieure e. V.
- VDW – Verein Deutscher Werkzeugmaschinenfabriken e. V.
- WGP – Wissenschaftliche Gesellschaft für Produktionstechnik
- Wirtschaftsverband Stahl- und Metallverarbeitung e. V.

Foundations

- Karl-Kolle-Stiftung
- VolkswagenStiftung

4 Further Activities

4.1 Conferences and Meetings

In 2011 the following 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.

- 10th International Conference on Technology of Plasticity, ICTP 2011 Aachen/Dortmund • in cooperation with Prof. G. Hirt, Institute of Metal Forming (IBF), Aachen, Germany • venue: Aachen • September 25 - 30
- 4th Tube and Profile Bending Conference (DORP) 2011 • venue: Dortmund • November 24 – 25
- International Conference on Extrusion and Benchmark (ICEB) • in cooperation with the Department of Mechanical Engineering (DIEM), Università di Bologna, Italy • venue: Bologna• October 3 – 5
- 1st Global Conference on Materials and Technology for the Future "Green Vehicle" • in Cooperation with the Nagoya University, Japan • venue: Dortmund • November 21
- 14th Workshop "Simulation in Forming Technology" • in cooperation with the Institute of Forming Technology, University of Stuttgart • venue: Dortmund • March 16 – 17
- 2nd Lightweight Symposium and Colloquium of the Collaborative Research Center Transregio10 • venue: Dortmund • February 15
- Workshop "Scientific Publishing" • in cooperation with the Research Training Group 1483, Karlsruhe Institute of Technology • venue: Karlsruhe • July 14
- AiF User Forum "Disortion in Cold Forging" • in cooperation with the Research Association for Steel Application (FOSTA) • venue: Düsseldorf • October 27
- Kick-off Workshop "EXIST – Die Gründerhochschule" • venue: Dortmund • October 20

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 30, July 1
- Girls' Day • April 14
- do-camp-ing 2011 • July 24 – 29
- SchnupperUni • September 1
- "Young Engineers" – Promotion of Young Scientists Starts in Kindergarten • February 23, April 4, April 8
- Alumni-Reunion • May 3

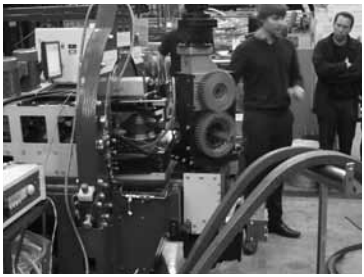
In the following, you will find more information on selected events.

International Conference on Technology of Plasticity (ICTP) 2011

The 10th International Conference on Technology of Plasticity (ICTP) was held in Aachen, Germany, on September 25–30, 2011. It was organized on behalf of the German Metal Forming Association (AGU) by the Institute of Metal Forming (IBF), Aachen, and the Institute of Forming Technology and Lightweight Construction (IUL), Dortmund. The interest in the conference was tremendous. More than 650 abstracts have been submitted from over 45 countries. A total of 424 papers was accepted after a reviewing process for presentation and inclusion in the conference proceedings. In addition, more than 40 papers have been accepted for a poster presentation. The ICTP 2011 included a number of distinguished events as the Kurt-Lange-Memorial-Session, the 2011 JSTP International Prize award for research & development in precision forging, and the Karl-Kolle-Prize award of the AGU. On the last day of the conference, six different technical tours have taken the participants to industrial visits at well-known companies in the region of Aachen and Dortmund. About 80 ICTP participants enjoyed a guided tour through the IUL experimental area.

4th Tube and Profile Bending Conference DORP 2011

This year the 4th Tube and Profile Bending Conference DORP 2011 was held on November 24 and 25, 2011, at the Congress Center of Westfalenhallen Dortmund. In response to the great feedback in the past years, DORP was organized as a two-day as well as international conference for the first time.
With this conference, there has been more room for interesting lectures, stimulating discussions, and an intense exchange of experiences and views between industry and science on an international level.
This year, we were very pleased to welcome Professor Murata from the University of Electro-Communications (UEC Tokyo) as our keynote speaker. Professor Murata is one of the most famous scientists in the field of tube bending technology. He is especially well-known for his MOS bending method as an innovative method in free form bending of tubes.
In addition to the interesting lectures companies had the opportunity as in recent years, to present an exhibition stand or act as sponsors during the event. The exhibition stands also generated interesting discussions. Furthermore, participants could visit the experimental area of the IUL and experience the innovative process at the institute.



Impressions of the DORP 2011

International Conference on Extrusion and Benchmark (ICEB)

The International Conference on Extrusion and Benchmark (ICEB) has become the biggest event in Europe related to recent developments in extrusion technologies and their analysis by FEM simulation. The conference takes place every two years and was organized this year by the Department of Mechanical Engineering (DIEM), University of Bologna, in cooperation with the IUL. Held on October 3 - 5, more than 140 delegates from over 26 countries attended the 2011 edition. With two-thirds of the participants coming from the industry and with representatives from all the multinationals of aluminum, a strong interest was evidenced in getting and sharing knowledge on these topics of technological innovation. The aim of the conference is to bring together technical and scientific experts, to widespread their knowledge, and to form an international community for the discussion of state of the art as well as future developments in the field of extrusion and its numerical simulation.

1st Global Conference on Materials and Technology for the Future „Green Vehicle“

On November 21, 2011, the IUL hosted the 1st Global Conference on Materials and Technology for the Future “Green Vehicle”. This conference was organized in cooperation with the Nagoya University (Japan) and was supported by the Japan Society for the Promotion of Science (JSPS). The chairmen of the conference were Prof. Kanetake (Nagoya University) and Prof. Tekkaya. Circa 30 international participants enjoyed 6 sessions of lectures on state-of-the-art technologies related to the future “green vehicle”. The bandwidth of the presentations ranged from innovative materials and manufacturing techniques for lightweight applications to biotechnology, plasma technology, and nanomaterials. The lecturers are renowned researchers and industry representatives from Japan and Europe, the keynote lecture “Realizing Sustainable Mobility” was given by Mr. Takada, Toyota Motor Europe. The event should serve as the starting point of a global network of scientists and engineers who can significantly influence the future developments in automotive industry.

Workshop „Simulation in Forming Technology“

On March 16 and 17, 2011 the workshop “Simulation in Forming Technology”, which was organized as collaborative project of the Institute of Forming Technology and Lightweight design and the Institute for Metal Forming of the University of Stuttgart, took place at TU Dortmund. “Evolution of microstructure in Sheet and Bulk Forming” was chosen as main topic for the 14th edition of the workshop. One day was dedicated to sheet and bulk forming, respectively.
Due to the speakers coming from industry, universities, and software companies, the topic microstructure evolution in forming simulation could be discussed from different perspectives. The current state of the art was presented and future developments were discussed. More than 70 participants from industry and academia could be welcomed to the workshop this year.

2nd Lightweight Symposium and Colloquium of the Collaborative Research Center Transregio10

The common research objective of the six institutes and chairs being part of the Collaborative Research Center Transregio10 (SFB/TR10) is to develop scientific fundamentals and methods for the design of integrated process chains for an automated and product-flexible batch size production of light frame structures. The demand for flexibility in the production refers in this context to the applicability for small batch sizes, a high diversity of variants as well as short-termed producibility.
At the Lightweight Symposium essential results were introduced. The audience consisting of the Industrial Advisory Board, business representatives, and researchers was offered the opportunity for interdisciplinary exchange during lectures presenting industrial research as well as fundamental research of the SFB/TR10. The presented results of the SFB/TR10 showed the integration of the individual processes and their combination with a production for lightweight structures.

Demonstration of the process chain

Workshop “Scientific Publishing”

On July 14, 2011, the Workshop “Scientific Publishing“ took place in Karlsruhe, organized by the Collaborative Research Center Transregio10 as a part of an employee training in cooperation with the Post Graduate Program 1483. Lectures like “An Editor’s Perspective“ and “How to get Published in Scientific Journals“ provided the participants with essential information about fundamentals of the scientific way of working, the possibilities of publishing in journals and their significance as well as important facts about author´s rights and responsibilities aligned with a publication. These lectures were given by Professor A. Erman Tekkaya, Editor-in-Chief of the Journal of Materials Processing Technology (Elsevier), together with Mrs. Rebecca Wilson and Mr. Christopher Greenwell, both publisher at Elsevier.

Participants in the Scientific Publishing Workshop

AiF User Forum

On October 27, 2011, the AiF User Forum on "Distortion in Cold Forging" was held in Düsseldorf. This event was organized by the Research Association for Steel Application (FOSTA) with the assistance of the IUL. The user forum offered representatives from industry and research the opportunity to share experiences on the topic of "distortion".
In addition to presentations from user from the economic sector also current results of university research were presented.

Kick-off Workshop EXIST

EXIST is a funding program of the Federal Ministry of Economics and Technology (BMWi) and part of the "High-Tech Strategy for Germany" of the government. In addition, EXIST is cofinanced by the European Social Fund (ESF) with a financial support of up to 5 million Euros over 5 years.
The goal of EXIST is to build up a new entrepreneurial culture and strength to entrepreneurship at universities. With the competition "Uiversity of Founders" ("EXIST-Gründerhochschule") favorable conditions are created to anchor the idea of entrepreneurship and to improve the utilization of scientific knowledge in start-ups.
The founding issue shall be applied at German universities - a holistic strategic approach that is supported by all relevant actors, including the university administration. Thus, the goals of the funding are to
• improve the climate for entrepreneurship and the spread of entrepreneurship within the universities and the
• increase of the number of technology-oriented and knowledge-based start-ups.
Among the most important people for this program are the promoters, like Professor A. E. Tekkaya. The promoters have the task to spread entrepreneurial thought among the students and to evaluate the ideas for new start-ups with in-depth expertise in the field of forming technology.

Stahl fliegt – Flying Steel

"Stahl Fliegt" (Flying steel) is an interdisciplinary ideas competiton for creatively thinking students which is supported by FOSTA (The German Research Association for Steel Application). The aim of this innovative steel-lightweight competition is to design an aircraft consisting of a steel with a percentage of iron of at least 70%, a maximum weight of 400 grams and a maximum size of 1 m^3. This competiton took place for the 11th time and was organized this year by the IUL. On June 30, 2011, teams of RWTH Aachen, TU Dortmund, TU Darmstadt, TU Munich, Saarland University Saarbrücken, University of West Bohemia in Pilsen (Czech Republic), University of Bremen, and University of Kassel presented their aircrafts in short presentations. The following day, the flight show took place in Hall 6 of the exhibitiongrounds Düsseldorf. Here, the aircrafts of the Teams of Bremen and Munich could convince the jury and finished as the three best teams.

Participants of "Stahl fliegt"

Girls' Day

The IUL listed the Girls' Day 2011 under the motto: „How is sheet metal turned into a car?". 30 girls at the age of 10 to 15 took the opportunity to gain insight into the metal forming technology. A presentation explained what forming technology actually is and where it is met in everyday life. By visiting the experimental area of the IUL the girls could experience forming technology manufacturing processes live. Particularly deep-drawing of cups and hoods was shown. At a hand-operated screw press they could have a try in coining. The group was supervised by Annika Foydl and Stephanie Gerke.

Girls' Day 2011

do-camp-ing

With do-camp-ing, Technische Universität Dortmund offers a new and exciting opportunity to orientate oneself before deciding on a major and to gain insights into the life of students. Participants spend one week on the university's campus and work in teams on interesting and challenging projects dealing with engineering topics. The aim is to figure out the participants' aptitude and vocation for a technical course of studies early enough and to get to know the way of working exemplary for their future studies.
In 2011, the IUL contributed the project "Design products made of sheet metal – forming technology makes it happen!". Participants had the opportunity to design a complete product development chain themselves – from the first draft to the finished product. They were challenged to design a CD rack for approximately twenty CDs made of one single stainless steel sheet by applying cutting and bending operations. Having presented a unique design concept, the IUL participants supervised by M.Sc. Volkan Güley were awarded this year's second prize among eight projects.

First draft...

Finished product...

Participants

SchnupperUni

At the end of the summer break interested secondary school senior class students have the opportunity to participate in a one-week introductory course at Technische Universität Dortmund. During the so called SchnupperUni ("Get to know your university!") more than ten faculties of TU Dortmund open their lecture halls and offer a first insight into university affairs in the form of lecture visits, tutorials, and experiments, especially in scientific and technical subjects. Experience reports, tips, and recommendations regarding the course of the engineering studies are often of great interest. 23 senior class students attended the metal-forming event at the IUL dealing with the topic: "How to form cars/ airplanes made of steel". The following questions could be resolved:

- Where is forming technology implemented?
- What is forming technology?
- What fields of activity are covered by forming engineers?

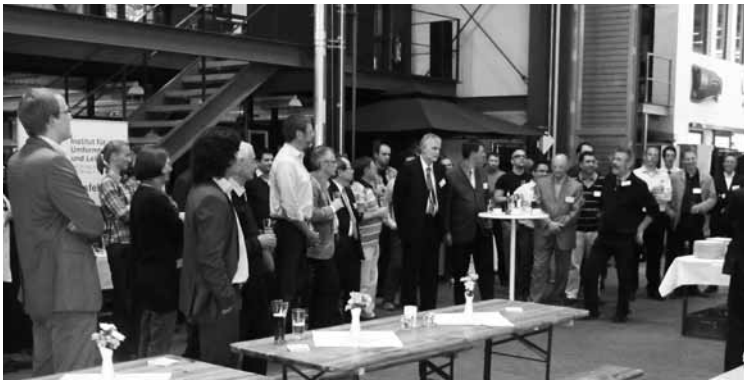
"Young Engineers" – Promotion of Young Scientists Starts in Kindergarten

For the first time, the IUL started with the promotion of "young scientists" of preschool age. Therefore, 25 children aged four to six years visited the IUL in the beginning of the 2011. During three events the young researchers had the chance experience research work at university. Starting with a small lecture, the basics of deep drawing and die extrusion of automotive parts were explained. Afterwards, a practical exercise in the experimental area took place, with coin embossing and sheet metal bending. To complete the impression of a student´s life at university, a visit of the canteen with "traditional" food is obligatory and was, of course, part of the program. All participants enjoyed the event very much, so this way of promotion will be continued in future years.

Impressions of the kindergarten visit at the IUL

Alumni Reunion

On May 3, 2011, the first IUL Alumni Reunion, organized by Mr. Becker and Mr. Gharbi, took place in the IUL experimental hall. All former employees of the institute had been invited for a snack and drink. After Professor Tekkaya welcomed the attendees with a short institute presentation on the current work of the IUL, the alumni were able to reminisce. They strolled through the hall and marveled at the current equipment. There was also a very interesting exchange of knowledge and experience between the former and current employees, so that this meeting represented a very fruitful get-together.



Alumni reunion 2011

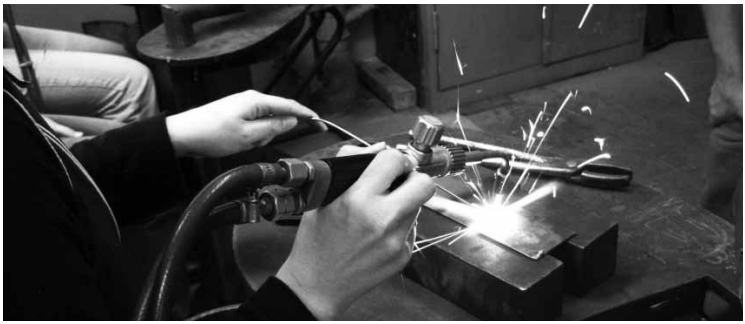
4.2 Equal Opportunities Activities

4.2.1 Holiday Care for School Children at the IUL

During the summer vacation 2011, from August 29 to September 2, for the third time a holiday care took place as part of the Collaborative Research Center Transregio 73 at the premises of the Institute of Forming Technology and Lightweight Construction (IUL).
Again, the IUL provided the necessary infrastructure, which included the use of two group rooms and a kitchen for housing activities for the care of 3 school children aged 8-10 and a small child at the age of 3. It also provided a small bus for excursions. The planning, organization, and childcare was taken over by a student of TU Dortmund and a student of Dortmund University of Applied Sciences. Beside various activities and creative workshops the excursions offered became a great experience for children of all ages (Sauerlandpark in Hemer, Legoland Discovery Center in Duisburg and Signal-Iduna-Park (guided tour through the stadium)). The lunch at the canteen on the campus grounds as well as the joint cooking, alternating from day to day, were also an essential feature of daily holiday care routine.

4.2.2 Efforts towards gender equality by providing insights into technical and engineering professions and processes: ”Seminar/Exercise Welding for Beginners”

“This was great. Not mere theory but we could also just try out ourselves!“ There was great enthusiasm among the participants about the two-day welding seminar, which was meant for women only and organized in co-operation of the collaborative research centers SFB 708 and SFB/TR10 within the frame of their efforts towards gender equality. The seminar consisted of a theoretical and a practical session. On the first day, Prof. Dr.-Ing. Reinhard Winkler of the Schweißtechnische Lehr- und Versuchsanstalt SLV Duisburg gave a lecture on the history of welding and introduced technical fundamentals, procedures, applications as well as safety rules. On the second day, the participants were invited to the SLV in Duisburg, where various welding procedures with different materials and joints were shown to them. On top of this, they had the opportunity to perform e.g. gas, TIG and MAG welding themselves.



4.2.3 Parent-Child-Room at the IUL

There are many different situations where employees of the IUL have to find a place for their children at short notice. Be it that school is off, the nanny can't come, or that the kindergarten is being renovated – quick help regarding childcare often is rare and expensive. Often employees have no other choice than to stay home and look after their children themselves. That is why a parent-child-room has been established at the IUL on the initiative of the Collaborative Research Center Transregio10. It is financed by the gender equality fund of the collaborative research center which is supported by the German Research Foundation. The room with about 18 m^2 is situated in the annex of the experimental hall. It enables employees of the collaborative research center to deal with short dated problems regarding childcare by taking their children along to work. Besides a fully furnished work area for the parents in their usual working environment, the parent-child-room also has furniture for the children with sleeping facility, diaper changing table, playing carpet, and numerous toys. The parents can also use a kitchen close by to provide sustenance for their offspring.

Deutsche Forschungsgemeinschaft DFG

Sonderforschungsbereich Transregio10

ELTERN-KIND-ZIMMER

4.3 Awards

Best Poster Award (ICTP)

The Department of Bending Technology has won the "Best Poster Award" at the International Conference on Technology of Plasticity. The prize was presented to the winning team during the "Olympics of Forming Technology" in Aachen. The poster by Christoph Becker, Daniel Staupendahl, Matthias Hermes, Dr. Sami Chatti, and Professor A. E. Tekkaya convinced the majority of the 700 conference members. They had the choice between 50 posters, thus declaring the winner of the "Best Poster Award". The poster of the Dortmund institute convinced with research results concerning innovative forming methods for the production of tubes and profiles. The prize was handed over to them during the "Olympics of Forming Technology" in Aachen.

Best Poster 2011 (ENBIS)

The fruits of the interdisciplinary cooperation of Professor Joachim Kunert, Professor A. Erman Tekkaya, Dr. Oliver Melsheimer, Dr. Simone Wenzel, Gerd Sebastiani, and Adrian Wilk have been decorated with the ENBIS 2011 best poster award. Their contribution entitled „Quantification of Sheet Thickness from Optical Measurements" describes a method for analyzing deviations in sheet metal parts from both, a statistical and technical perspective. Reported achievements contribute to the Collaborative Research Center 823, which is aimed at facilitating the synergy in research by combining engineering, statistics, and economics to interdisciplinary task forces.

Most Innovative Paper

Under the aegis of Her Royal Highness Princess Sumaya bint El Hassan, president of the El Hassan Science City and the Royal Scientific Society, the second international IEEE Engineering Education Conference, EDUCON 2011, took place from April 4 to 6, 2011, in Amman, Jordan, on the subject of "Learning Environments and Ecosystems in Engineering Education". In the context of this conference the contribution "Platform for E-Learning and Telemetric Experimentation (PeTEX) – Tele-Operated Laboratories for Production Engineering Education" was honored as "Most Innovative Paper" by Princess Sumaya University for Technology" (Amman, Jordan). The paper was prepared and submitted by Prof. A. E. Tekkaya and Mr. C. Pleul in cooperation with Jun.-Prof. Dr. I. Jahnke and Mr. C. Terkowsky (Center for Research on Higher Education and Faculty Development (HDZ, TU Dortmund)).


EDUCON2011

Certificate
IEEE EDUCON2011
Princess Sumaya University for Technology
Amman, Jordan
4-6 April 2011
www.educon-conference.org

This is to certify that
Claudius Terkowsky, Christian Pleul, Isa Jahnke and A. Erman Tekkaya
has presented the paper entitled:
"Platform for E-Learning and Telemetric Experimentation (PeTEX) "
and has been awarded the
"Most Innovative Paper"
in the Second Global IEEE Engineering Education Conference, EDUCON2011
"Learning Environments and Ecosystems in Engineering Education"

IEEE

POLITÉCNICA

FACHHOCHSCHULE KÄRNTEN

Best Paper Lightweight Construction

From July 8 - 9, a WGG Annual Congress took place in Berlin the first time. The congress was attended by about 200 scientists as an exchange platform for knowledge and experiences. More than 60 presentations with the main topics electric mobility, medical engineering,, resources efficiency, lightweight construction and capability for mass production were presented. The submitted paper "Flexible Manufacturing of Lightweight Frame Structures with an Integrated Process Chain" by D. Pietzka and Prof. A. E. Tekkaya received the best paper award for the topic lightweight construction. The paper showed an overview of the work and the integrated process chain of the Collaborative Research Center Transregio10.

"100 Women of Tomorrow"

Annika Foydl, member of the Department of Bulk Metal Forming, was honored as one of „Tomorrow's 100 Women". The regional initiative "Germany – Country of Ideas", a joint project of the Federal Government and German economy under the aegis of the Federal President Christian Wulff, honors young women whose innovate and creative ideas will have a lasting effect on future economy, society, and politics in Germany. The laureates were selected by an all-women jury with members like Dr. Ingrid Hamm, chief executive officer of Robert-Koch-Stiftung, and Rita Forst, member of the Opel directorate. Ariane Derks, the initiative's chief executive officer, résumés: "As different the 100 women are, they have one thing in common: They believe in the power of ideas and that they can be made a reality."

4.4 Further Education

For staff members of the Institute of Forming Technology and Lightweight Construction further education goes without saying. Listed below, you find a selection of key aspects of further training.

Further Education Science and Theory

- Compact seminar “Residual Stresses” • June 21, 2011 • Integrated Research Training Group of the Collaborative Research Center TRR30 • University of Kassel • Kassel
- Workshop “Scientific Publishing” • July 14, 2011 • Collaborative Research Center TR10 and Research Training Group 1483 • Karlsruhe Institute for Technology • Karlsruhe
- Workshop “Team Work & Leadership Competencies in Academia and Beyond: Youngsters – Team Player – Key Player” • August 3, 2011 • Collaborative Research Center 832 Academy • Dortmund
- Seminar “Office Management Network” • September 13, 2011 • Center for Continuing Education • Technische Universität Dortmund • Dortmund
- WGP Assistant Meeting • September 14 – 16, 2011 • German Academic Society for Production Engineering • Saarbrücken
- Special training Calypso Basics • September 19 – 23, 2011 • Carl Zeiss Messtechnik GmbH • Dortmund
- Information day “Basics of Experimental Strain and Stress Analysis” • September 20, 2011 • Hottinger Baldwin Messtechnik GmbH • Lünen
- Workshop “Basics of Strain Measurement Technology” • Septmeber 21, 2011 • Hottinger Baldwin Messtechnik GmbH • Lünen
- Workshop “Measurement Technology - Practical Training” • September 22, 2011 • Hottinger Baldwin Messtechnik GmbH • Lünen
- PhD student seminar of the the Graduate School of Energy Efficient Production and Logistics • September 30, 2011 • Dortmund
- Compact seminar “Introduction to Statistical Design of Experiments” • October 5 – 6, 2011 • Collaborative Research Center 708 Academy • Dortmund

- Research Day 2011 • November 10, 2011 • RUB Research School • Bochum
- Equal opportunities activity "Seminar/Exercise Welding for Beginners" • October 14, 2011 and October 17, 2011 • Collaborative Research Center 708 and TR10 • Duisburg
- Science College 2011 • October 18, 2011 • RUB Research School • Bochum
- Compact seminar "Milling and Grinding" • December 12, 2011 • Collaborative Research Center 708 Academy • Dortmund

Further Education Software

- Finite Element Model Setup with HyperMesh – Basics • July 4 – 6, 2011 • ALTAIR Engineering GmbH • Böblingen
- Introduction to Power Point • November 15 – 16, 2011 • Center for Continuing Education • Technische Universität Dortmund • Dortmund

Further Education Teaching

- Workshop "Scientific Writing in Teaching for Tutors of the Faculty of Mechanical Engineering" • March 1, 2011 • Center for Continuing Education • Technische Universität Dortmund • Dortmund

Soft Skills and Social Competences

- Seminar "Intercultural Competences" • March 10 – 14, 2011 • Graduate School of Energy Efficient Production and Logistics • Dortmund
- Seminar "Successful Presentation" • October 17 – 18, 2011 • Center for Continuing Education • Technische Universität Dortmund • Dortmund
- Seminar "Basic Scientific Presentation" • November 7 – 9, 2011 • RUB Research School • Bochum

Operational and Occupational Safety

- The new categorization and labelling of dangerous material • February 2, 2011 • Center for Continuing Education • Technische Universität Dortmund • Dortmund
- Radiation Protection Course, Basic Module according to RöV Module A (R3) • November 14, 2011 • Training Facility for Radiation Protection at Aachen University of Applied Sciences • Jülich
- Radiation Protection Course, Basic Module according to RöV Module G (R2) • November 15 – 16, 2011 • Training Facility for Radiation Protection at Aachen University of Applied Sciences • Jülich

Furthermore, numerous staff members attended first-aid seminars, fire control trainings as well as courses to acquire a crane driver´s license.

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

Memberships of Research Boards

- CIRP - Fellow of the “The International Academy for Production Engineering”
- acatech – Member of the “German Academy of Science and Engineering” (“Deutsche Akademie der Technikwissenschaften”)
- AGU – Member of “Wissenschaftliche Arbeitsgemeinschaft Umformtechnik“
- GCFG – Member of the ”German Cold Forging Group”
- ICFG – President of the “International Cold Forging Group” (until September 2011, then vice president)
- JSTP – Member of “The Japan Society for Technology of Plasticity”
- ICTP – Member of the Standing Advisory Board of the “International Conference on Technology of Plasticity” and co-organizer of “ICTP 2011”
- I2FG –Vice chairman and founding chairman of the “International Impulse Forming Group”
- DGM – Member of ”Deutsche Gesellschaft für Materialkunde“
- ICEB – Chairman of the “International Conference on Extrusion and Benchmark”
- Member of the “International Scientific Advisory Council” of the “Institute of Mechanical Engineering” (IDMEC) and “Associated Laboratory for Energy, Transports, and Aeronautics” (LAETA), Lisbon, Portugal
- ESAFORM – Member of the Scientific Committee of the “European Association for Material Forming”
- Honorary member of the “TechNet Alliance”
- Guest professor at Shanghai Jiao Tong University, Shanghai, China
- Curatorship member of “Karl-Kolle Stiftung“, Dortmund, Germany
- Founding director of the “Center of Excellence for Metal Forming”, Atilim University, Ankara, Turkey
- Member of the Scientific Advisory Board of “Exzellenzcluster Integrative Produktionstechnik für Hochlohnländer”, RWTH Aachen University, Germany
- Vice president of the consortium of “Deutsch-Türkische Universität” (German-Turkish University)

Journals/Editorship

- Editor-in-Chief, "Journal of Materials Processing Technology" (Elsevier)
- Subject Editor for Forming, CIRPedia (Springer-Verlag)
- Member of the Editorial Board, "CIRP Journal of Manufacturing Science and Technology"(Elsevier)
- Member of the International Editorial Board, Journal "Computer Methods in Materials Science"
- Member of the Scientific Circle, Journal "Steel Grips – Journal of Steel and Related Materials"
- Member of the International Advisory Committee, "International Journal of Material Forming" (Springer)
- Member of the Scientific Editorial Board, "International Journal of Precision Engineering and Manufacturing" (Springer)
- Member of the International Advisory Committee, "Romanian Journal of Technical Sciences - Applied Mechanics"

Further Memberships

- Turkish-German Cultural Association, Ankara, Turkey
- DAAD Scholar Committee, Ankara, Turkey
- IUTAM – "Turkish Branch of the International Union of Theoretical and Applied Mechanics", Turkey
- Member of the Scientific Committee, 11th International Conference on Numerical Methods in Industrial Forming Processes (NUMIFORM 2013), Shanghai, China
- Member of the International Program Committee, "International Conference on Machine Design and Production 2012" (15th UMTIK), Pamukkale, Denizli, Turkey
- Member of the International Program Committee, "5th International Conference and Exhibition on Design and Production of Machines and Dies/Molds 2011", Ankara, Turkey
- Member of the Scientific Committee of the "12th International Cold Forging Congress" (ICFC 2011), Stuttgart, Germany
- Member of the International Committee of the "3rd International Conference on Distortion and Engineering" (IDE 2011), Bremen, Germany

- Member of the International Scientific Committee of the "14th International Conference on Sheet Metal" (SheMet 2011), Leuven, Belgium
- Member of the International Scientific Committee of the "8th International Conference and Workshop on Numerical Simulation of 3D Sheet Metal Forming Processes" (Numisheet 2011), Seoul, Korea
- Member of the eLEARNing-TUDo2011 Program Committee, Dortmund, Germany
- Member of the Scientific Committee of the "International Deep Drawing Research Group" (IDDRG 2011), Bilbao, Spain
- Member of the International Scientific Committee of the "3rd International Conference on New Forming Technology" (ICNFT 2012), Harbin, China

Activities as Reviewer

In Scientific Committees

- DFG – German Research Foundation
- AiF – German Federation of Industrial Research Associations
- Research Council of Norway, Oslo, Norway
- Sabanci University, Istanbul, Turkey
- Atilim University, Ankara, Turkey
- University of New Hampshire, Durham, NH, USA
- Loughborough University, Loughborough, UK
- Universität Stuttgart, Stuttgart, Germany
- Hochschule für Technik, Wirtschaft und Kultur Leipzig (HTWK), Leipzig, Germany
- "Industrieverband Massivumformung"" (IMU), Hagen, Germany

For Journals

- Journal of Computational Materials Science
- Surface and Coatings Technology
- ASME – Journal of Manufacturing Science and Engineering
- International Journal for Numerical Methods in Engineering
- Journal of Materials Processing Technology
- Materials Science & Engineering A
- International Journal of Mechanical Sciences

4.6 Participation in National and International Organizations: Prof. Dr.-Ing. Matthias Kleiner

- Academia Europaea
- acatech – German Academy of Science and Engineering
- AGU – Wissenschaftliche Arbeitsgemeinschaft Umformtechnik
- AiF – German Federation of Industrial Research Associations (Curatorship Member)
- Berlin-Brandenburgische Akademie der Wissenschaften
- Adviser of Siepmann-Werke
- Adviser of Winkelmann Group
- CIRP – The International Academy for Production Engineering
- Deutsche Telekom Stiftung (Curatorship Member)
- Dr. h.c. of the Technical University of Cluj-Napoca
- German Academy of Sciences Leopoldina
- European Academy of Sciences and Arts (Member)
- FOSTA - Research Association for Steel Application (Curatorship Member)
- LOEWE Program (Member of the Advisory Board)
- SATW – Swiss Academy of Engineering Sciences (Member)
- Steel Institute VDEh
- Stifterverband für die Deutsche Wissenschaft (Ex Officio Member of the Executive Board)
- VDI – The Association of German Engineers
- WGP – German Academic Society for Production Engineering

5 International Scientists at IUL

Prof. Tudor Balan

In March 2011, Prof. Tudor Balan from the "Ecole Nationale Supérieure d'Arts et Métiers (ENSAM) ParisTech" (Metz Campus), department "Mechanics, Materials, Processes", "Laboratory of Physics and Mechanics of Materials" was a guest of the IUL. His visit was part of the Collaborative Research Center SFB 708 ("3D Surface Engineering of Tools for Sheet Metal Forming"). Prof. Balan's research activity addresses the numerical simulation of metal forming, with a focus on constitutive modeling and related problems. An important part of his two-day visit was the lecture "An approach to anisotropy modeling in sheet metal forming simulation".

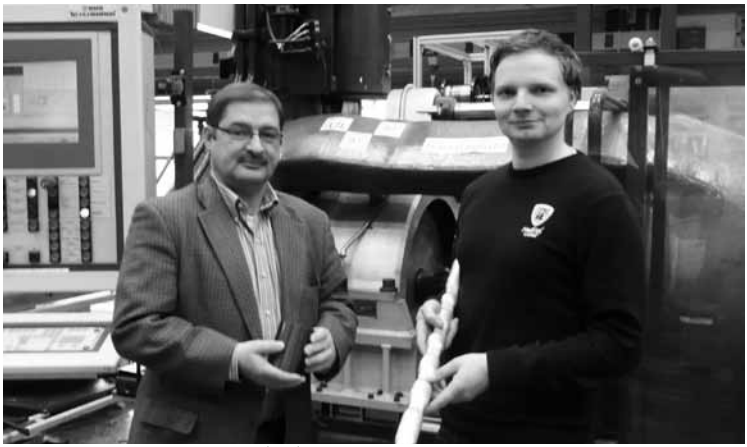
Prof. Brad Lee Kinsey

Prof. Brad Lee Kinsey of the Department of Mechanical Engineering and Materials Science, University of New Hampshire, USA, visited the IUL in May 2011. In presentations on the topics "Electrical-Assisted Forming", "Electromagnetic Forming", and "Electromagnetic Flanging" an overview on current developments in high speed forming was given. Prof. Kinsey's stay was financially supported by the DFG project SFB/TR30.

Prof. Wojciech Z. Misiolek

Wojciech Z. Misiolek, the Loewy Professor of Materials Forming and Processing from Lehigh University in Bethlehem, PA, USA, spent second half of 2011 at IUL, supported by the DFG as a "Mercator Visiting Professor". He did close collaborate with the IUL, research staff working with the graduate students and advising Ph.D. candidates. On the teaching front he was involved in launching the M.S. program in manufacturing technology that was offered in English for the first time this year. He has helped in preparation of class lectures and taught selected classes on metal forming in this new program. The Mercator professorship enabled Professor Misiolek to give presentations in Germany and other European countries about his use of numerical modeling packages and microstructure characterization to refine and control metal forming processes. Professor Misiolek gave the keynote address at the 10th International Conference on the Technology of Placticity (ICTP) in Aachen, Germany, in September, focused on modeling of microstructure response to deformation parameters in se-

lected metal forming processes. In October, he gave a plenary lecture at the Fourth International Conference on Extrusion and Benchmark in Bologna (ICEB), Italy, on numerical modeling of extrusion welding in magnesium alloys.



Professor Wojciech Z. Misiolek (left)

He also gave a series of research seminars to his colleagues at Technische Universität Dormund, at the AGH - University of Science and Technology in Krakow, Poland, his alma mater, and others.

Prof. Jian Cao

Prof. Jian Cao is head of the Advanced Materials Processing Laboratory at the Northwestern University in Evanston, USA, and was a guest of the IUL in August 2011 within the scope of the Collaborative Research Center 708. With lectures concerning surface engineering of forming tools and incremental forming she presented her latest research results at the IUL. Prof. Cao is an internationally accepted expert in the fields of metal forming and material modeling.

Prof. Yoshinori Yoshida

During the first part of his visiting period in Dortmund from August 9 to October 5, 2011, Prof. Yoshinori Yoshida's (Gifu University, Japan) research work concentrated on parameter identification for coupled phenomenological damage models as well as on validation studies

with cutting simulations. In a close collaboration with Department of Applied Mechanics in Forming Technologies (DAMFT), this study has been performed to investigate the predictive capability of the Lemaitre damage model enhanced with crack closure effects for shearing, i.e. low triaxiality, processes. The parameter identification could be made after an inverse analysis, where the experiments were already realized for notched tensile test specimens with different notch radii together with a digital monitoring of the notch during deformation history. Identified parameters will be used in cutting process simulations for validation during second visit of Prof. Yoshida in March 2012.

Prof. Glenn S. Daehn

Within the scope of Transregio10 Prof. Glenn S. Daehn, head of the Department of Materials Science and Engineering (MSE) at Ohio State University in Columbus, USA, was a guest of the Institute of Forming Technology and Lightweight Construction (IUL) in September 2011. Prof. Daehn is a worldwide accepted pioneer in the field of electromagnetic forming. Meanwhile the IUL can look back on many years of fruitful cooperation with Prof. Daehn which is manifested by a continuous exchange of employees as well as by the jointly organized "International Conference on High Speed Forming – ICHSF".

Dr. Sergey F. Golovashchenko

Dr. Sergey F. Golovashchenko is chief technical officer of "Manufacturing Research" at Ford Motor Company in the USA. Within the scope of Transregio 30 Dr. Golovashchenko was a guest of IUL in September 2011 when he most impressively presented fundamental knowledge as well as the latest research results on the subject of electromagnetic and electrohydraulic forming. Projects in this field currently in progress at the IUL were discussed in detail and further domains for future research could be initiated.

Dr. Takahiro Ishiguro

During the first part of his visiting period here, from October 1 to November 24, 2011, Dr. Takahiro Ishiguro's (Nagoya University - Japan) research work concentrated on FE analysis of single-side piercing processes for hollow forging products. In a close collaboration with the Department of Applied Mechanics in Forming Technologies (DAMFT), this study has been performed to investigate the influence of strain

distribution on piercing processes and sheared surface geometries. In this period, an identification of material characterization and an FE analysis of the extrusion process was carried out. Material characterizations, e.g. flow stress curve, critical damage value, were obtained, through tensile tests by using notched round specimens. The extrusion analysis was performed by changing material, extrusion ratio, bottom thickness of forged shape, and damage criteria. A Cockcroft & Latham (CL) model, Oyane model, and McClintock model was applied to the simulation as a damage criterion. It became clear that extrusion ratio and thickness affect the strain distribution and damage distribution drastically. Furthermore, it seems that a CL model could predict fracture successfully in piercing processes. Modeling of single-side piercing and extrusion experiments will be carried out as next stage on the basis of analytical results. The second half of Dr. Ishiguro's stay will start in June 2012.

Dr. Francesco Gagliardi

On November 1, 2011, Dr. Francesco Gagliardi from the University of Calabria, Italy, started his one-year research stay at the IUL. As guest scientist of the Collaborative Research Center SFB TR10, Dr. Gagliardi will carry out experimental work and numerical extrusion experiments.

Dr. Erhardt Lach

Dr. Erhardt Lach from the French-German Research Institute visited the institute on December 2, 2011. Dr. Lach is an expert in material characterization at high strain rates. He gave a 75-minutes lecture entitled "Introduction to the dynamic material testing". In addition, he participated in the discussion for the evaluation of the results of the project PAK343 (first funding period).

M.Sc. Zhenming Yue

Mr. Zhenming Yue is a doctoral student visiting the IUL within the scope of a joint doctoral program. He does his second year of doctoral research at the IUL, financed by the CSC (Chinese scholarship committee). He spent the first year of his research stay at the Université de Technologie de Troyes (UTT), Institut Charles Delaunay (LASMIS), mentored by Professor K. Saanouni. The topic of his thesis is damage prediction in sheet metal forming. His work uses the advanced material constitution model developed in France to accurately predict fracture in sheet

metal forming. The constitution model needs to be enhanced based on the tests conducted at the IUL. Up to now, the standard tensile test and the pre-notched tensile test have been finished and he is doing the data evaluation and will continue his research work by conducting the shear tests.

Matej Hudovernik, univ.dipl.inž

Matej Hudovernik works at TECOS – Slovenian Tool and Die Development Center and does his doctorate at the University of Ljubljana, Slovenia. His PhD topic is the numerical investigation of the TSS bending process, which has been developed at the IUL over the last years. In the course of his PhD program he spent a research period at the IUL from mid October until the end of December. Here, he focused on the numerical investigation of induction heating during the bending of profiles. In 2012, he is expected to spend another research period at the IUL from March until August.

Guest Students

Sonia Belkacem

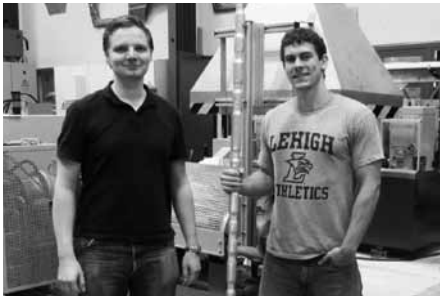
In 2011, the IUL supervised a joint Master's thesis in cooperation with Prof. Abdelwaheb Dogui, Head of the Department of Mechanical Engineering of the Ecole Nationale d'Ingenieurs de Monastir (ENIM). The Tunisian student Sonia Belkacem received the topic of her thesis ("Modeling and FE simulation of the 3D bending process of open and closed profiles") in September 2010 and had, prior to this, developed the models for a numerical simulation of the TSS bending process in Tunisia. From March to May 2011 Sonia Belkacem spent three months at the IUL as guest student and scholarship holder of the Tunisian Ministry of Higher Education and Scientific Research to validate the result of her experiments and to improve the simulation models. Subsequently, she successfully completed her Master's thesis at the partner university ENIM in October 2011. Sonia Belkacems thesis, originating from this first-time cooperation between IUL and ENIM, was graded "very good".

Carla Adriana Theis Soares and Lorenzi Moreira de Freitas

In August, Carla Adriana Theis Soares and Lorenzi Moreira de Freitas arrived at the IUL for a six months research stay within the framework of the German-Brazilian research project on cold drawing. As part of their research activities, the guest students from UFRGS (Universidade Federal do Rio Grande do Sul) in Porto Alegre, Brazil, have carried out FEM simulations aiming at the determination of residual stresses and the distortion of anisotropic material.

RISE (Research Internships in Science and Engineering)

RISE is a summer internship program for undergraduate students from the United States, Canada, and the UK in the fields of biology, chemistry, physics, earth sciences, and engineering, provided by the German Academic Exchange Service (DAAD). It offers unique opportunities for undergraduate students to work with research groups at universities and research institutions across Germany for a period of 2 to 3 months during the summer. RISE interns are matched with doctoral students whom they assist and who serve as their mentors. Within this program, Patrick M. Holmes, a student from Lehigh University, Bethlehem, PA, USA, had the opportunity to work from May - August 2011 on a research project at the IUL, supervised by Andreas Jäger, analyzing the influence of high speed forming conditions on the microstructure development during electromagnetic forming subsequent to aluminum extrusion. To help covering living expenses, Mr. Holmes was financially supported by a grant partly covered by the DAAD and the Integrated Graduate School (MGK) of the DFG Collaborative Research Center SFB/TR30.



Guest student P. M. Holmes (right) and his mentor A. Jäger

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
- Screw press, 3,15 MN, Weingarten PS 180, 3150kN
- C-frame-eccentric press, 630 kN, Schuler PDR 63/250
- Hydraulic drawing press, 1.000 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

Further Forming Machines

- Swivel bending machine, FASTI 2095
- Press brake, 110 kN, HERA COP 110/3100
- 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
- Mandrel bending machine, Schwarze-Wirtz CNC 60
- 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
- Anlage zur elektromagnetischen Umformung, 6 kJ, Poynting SMU 0612 FS
- Machine for electromagnetic forming, 32 kJ, Maxwell Magneform 7000

Material Testing Machines

- Bulge-testing machine, 200 kN, Erichsen 142/20
- Universal testing machine, Zwick 1475 100 kN
- Universal testing machine, Zwick SMZ250/SN5A
- Vertical testing machine, Zwick FR250SN.A4K, Allround Line
- Plastometer, IUL 1 MN

Measurement Technique and Electronics

- Large volume SEM, Mira XI by Visitec (in cooperation with the "Institut für Spanende Fertigung" and "Lehrstuhl für Werkstofftechnologie, TU Dortmund)
- 3D-coordinate measurement machine, Zeiss PRISMO VAST 5 HTG (in cooperation with the "Institut für Spanende Fertigung", TU Dortmund)
- 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, 2 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

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
- 6-axes robot, KUKA-Industrieroboter KR 5 sixx R650
- 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

6.2 Hardware and Software Equipment

General Equipment

- Different Servers and approx. 220 networked workstation PCs with an extensive periphery

Hardware for Simulation Technology in the Field of FEM and Software Development

- Linux Cluster with 4 nodes with altogether 12 processing units

Operating Systems and Software Applications

- Windows 7 Professional
- Office 2010 Professional

- Diverse Adobe products, as for example Photoshop, Acrobat, InDesign, Illustrator
- Corel Designer X4

CAD

- Unigraphics
- Catia
- AutoCad
- Mechanical Desktop

FEM Special Purpose

- Pam Stamp
- Autoform
- Hyperworks/HyperXtrude
- Deform
- QForm
- Superform

FEM General Purpose

- MARC
- Ansys
- Abaqus
- LS-Dyna

Mathemetical-Technical Calculation Programs

- Maple
- Mathcad
- Matlab