Institute of
Forming Technology and
Lightweight Construction

Activity Report

09

technische universität
dortmund

Impressum

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Content

Preface

Dear reader,

The year 2009 has again been highly successful for the Institute of Forming Technology and Lightweight Construction and we owe this success once more largely to our committed and smart staff members as well as to our excellent partners. In a tried and tested way, this report comprises a roundup of our various activities regarding education and research, the transfer of knowledge and services in economy and society as well as our intensive international cooperation.

In December 2009, Professor Tekkaya accepted the full professorship at the Institute of Forming Technology and Lightweight Construction offered by Technische Universität Dortmund and, after almost three years of substitute professorship, we are both glad about the institute's management being completed by a second professorship. We would like to thank the University's Rector, Professor Ursula Gather, for this offer and for our many years of excellent cooperation.

Professor Kleiner was re-elected as President of the German Research Foundation (DFG) for a further period of three years. As a research funding organization, the DFG contributes to strengthening fundamental research in Germany, particularly in higher education, fostering its broad diversity and high quality.

Professor Tekkaya will, in addition to his activities in Dortmund, continue to direct the Center of Excellence on Metal Forming at Atilim University in Ankara, Turkey's largest research center with a total area of 3500 m2 and excellent state-of-the-art facilities. Thus, a close cooperation between this center and the IUL will arise and open up a vast number of synergistic benefits and new perspectives to intensify our research activities.

The institute and its educational and research tasks have grown once more in 2009. The fact that we are now employing 45 scientific staff members may be a striking indicator for this development.

In the period under report we could initiate or continue international research activities with Brazil, China, France, Great Britain, Italy, Japan, the Netherlands, Poland, Portugal, Slovenia, Spain, Sweden, the USA, Taiwan, Tunisia, and Turkey. This specifically applies to the great cooperation with our friends and colleagues of CIRP. We will continue to expand and intensify our European and international cooperation projects. These partnerships do not only create scientific and technological synergies, but also constitute the basis for trust, friendly relations, and cross-cultural understanding. Sincere thanks go to the prestigious Technical University Cluj-Napoca (Romania) which has awarded an honorary doctorate to Professor Kleiner in November 2009.

Our cooperation with German universities and institutions has also been multifaceted and fruitful. In this context, we did not only cooperate with our friends and partners of AGU and WGP, but also with colleagues from the fields of mechanics, materials engineering, turbomachinery, design, civil engineering, electrical engineering, mathematics, computer sciences, physics, and statistics.

In 2009, we have been able to initiate or continue various projects in cooperation with the local industry, funded by AIF, FOSTA, BMBF, GCFG, DFG (transfer projects), and the European Union, thus fulfilling our task regarding the transfer of knowledge from basic research activities. The growing number of patent applications originating from the IUL is not only evidence of a traditional inventiveness, but also encourages us to step up our efforts in order to increase the number of spin-offs emerging from the IUL. This is the quickest possible and most effective way to put our ideas into practice.

The further growing number of students is highly pleasant. However, additional measures are necessary to ensure the quality in teaching according to the Bologna Accords and to reach an excellent standard. We want to contribute actively to an improvement and strengthening of teaching methods for the benefit of students and academic staff.

Concluding, we would like to thank all those institutions promoting our research, the numerous industrial enterprises as well as all university colleagues cooperating with our institute. And finally, we would, of course, like to express our special thanks to all staff members of the Institute of Forming Technology and Lightweight Construction who have achieved the institute's success by contributing their exemplary commitment and skills.

Sincerely,

Matthias Kleiner

A. Erman Tekkaya

In 2009 we have been shaken by the sad news of Professor Kurt Lange's death. My esteemed teacher and mentor died unexpectedly, shortly before his ninetieth birthday. Experts will sorely miss this precise, consequent, and honorable scientist. I feel concerned about a growing concep-tual confusion in the field of forming technology and increasingly appreciate Professor Lange's contribution to this topic.
Unfortunately, Professor Elmar Steck, a former colleague of Professor Lange and pioneer of nu-merical methods in forming technology, also died in 2009. Many of his methods are still being applied in forming technological analysis processes.

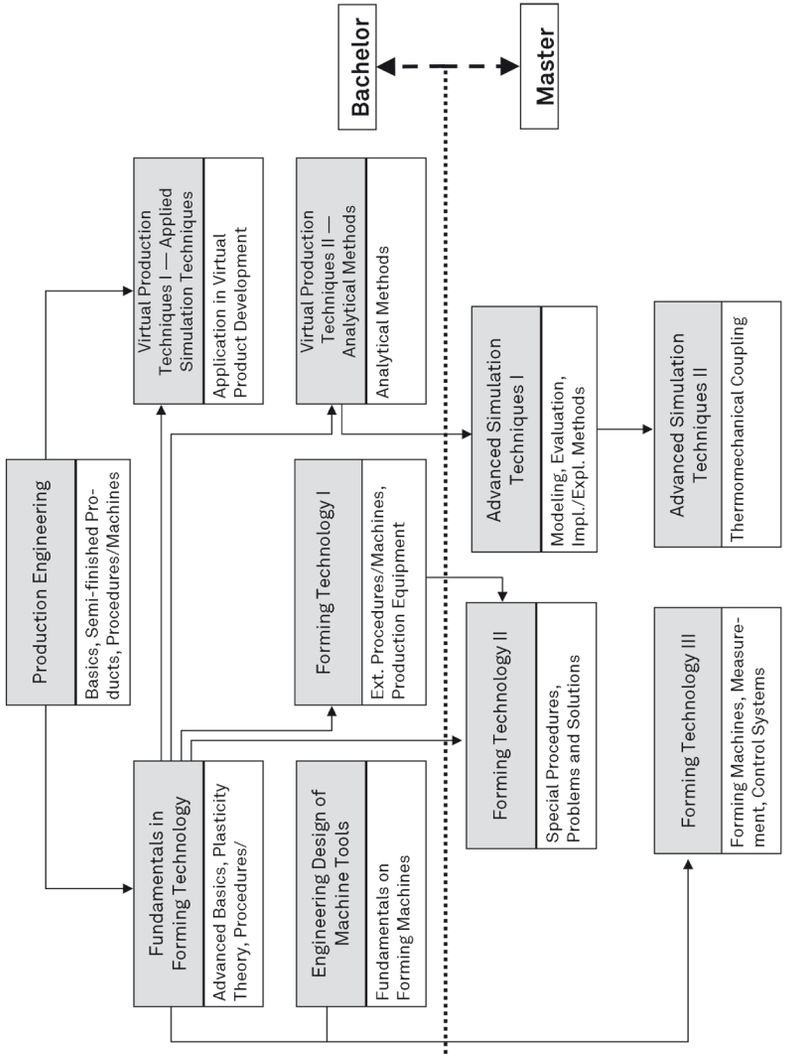
A. Erman Tekkaya

1 Education

1.1 Lectures

The bachelor courses Mechanical Engineering, Industrial Engineering and Management, and Logistics have started successfully in winter semester 2008/2009. Corresponding master courses will start as from summer semester 2010. IUL has taken this opportunity to restructure the courses and the content of the lectures, see figure.

The lecture Production Engineering is provided in cooperation with the Institute of Machining Technology (ISF). The part of the IUL presents basics in forming technology with main focus on manufacturing of semi-finished products, massive forming, and sheet metal forming. The lectures Fundamentals in Forming Technology and Forming Technology I-II deepen this technological knowledge with a detailed presentation of advanced basics, procedures, and process chains. Information about forming machines, measurement, and controlling is presented in the lectures Engineering Design of Machine Tools and Forming Technology III. These lectures focusing rather on different forming processes are complemented by lectures titled Virtual Production Techniques I-II and Advanced Simulation Techniques I-II, which concentrate on simulation methods in forming technology.



1.2 Offered Courses - Content

The Institute of Forming Technology and Lightweight Construction teaches mainly students majoring in logistics, industrial engineering, and mechanics, and also 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 particular lectures are presented.

Production Engineering – Subject “Forming Production”

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

In cooperation with the Institute of Machining Technology

Scope 2 L
Date winter semester

Content IUL

The course „Production Engineering“ gives a general view of the processes and machines of forming production. The course is held in cooperation with the Institute of Machining Technology (ISF). The ISF starts with an introduction to machining technology and the IUL continues with a presentation of primary shaping and forming.

- 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, 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.-Wirt.-Ing D. Pietzka • Dipl.-Ing. A. Jäger

Scope 2 L + 1 T
Date winter semester

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

- Metallurgical fundamentals in forming technology
- Flow curve, theory of plasticity, and friction models
- Material characterization
- Membrane theory
- Form 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 through individual forming processes

Forming Technology I / Forming Technology in Industrial Engineering and Management

Prof. Dr.-Ing. A. E. Tekkaya • Dr.-Ing. habil. S. Chatti
Dr.-Ing. Dipl.-Wirt.-Ing. D. Becker • Dr.-Ing. Dipl.-Wirt.-Ing. M. Marré

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, and manufacturing resources which have not yet been discussed are explained in detail.

- Extrusion
- Reducing, ironing, and drawing
- Metal spinning processes
- Roll forming
- Profile bending and tube bending
- Planning of methods
- Mechanical handling
- Automation
- Optimization and simulation
- Energy, environment, and safety

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 I

Prof. Dr.-Ing. A. E. Tekkaya • Dr.-Ing. M. Trompeter • M.Sc. V. Franzen
In cooperation with the Institute of Machining Technology (ISF)

Scope 2 L + 1 T
Date summer semester

Content IUL

The lecture „Engineering Design of Machine Tools I“ introduces the relevant fundamentals with regard tothe 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 capacity utilization
- Bending and rolling machines
- Servo presses and special purpose machines

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

Prof. Dr.-Ing. A. E. Tekkaya • Dr.-Ing. Dipl.-Inform. U. Dirksen
Dipl.-Inform. A. Selvaggio

Scope 2 L + 1 T
Date winter semester

The lecture „Methods of Virtual Production I“ or „Simulation Methods in Forming Technology I“ discusses the virtual product development process with respect to forming aspects, aiming at a fully computer-based and synchronized product development process.

- Relevance of virtual production and virtual product development
- History and components of the virtual product development process
- Technical basics (workplace with 3D-input device, 3D-visualization)
- Virtual design (CADsystem, conference systems, modeling,
- parametrical modeling, feature based modeling)
- Knowledge-based engineering
- Product Data Management Systems (PDMsystems)
- Date exchange type
- Simulation systems
- Optimization systems
- Virtual product development in automobile and airplane industry

Forming Technology II

Prof. Dr.-Ing. A. E. Tekkaya • Dipl.-Ing. V. Psyk • Dr.-Ing. D. Risch
M.Sc. G. Sebastiani • Dr.-Ing. Dipl.-Wirt.-Ing. D. Becker
Dipl.-Ing. T. Kloppenborg • Dipl.-Ing. H. Karbasian

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

The lecture „Forming Technology II“ deals with special procedures of forming technology..

- Super plastic forming
- High-speed forming
- Incremental forming
- Thixoforming
- Special extrusion procedures
- Micro forming procedures
- Hot sheet metal forming
- Seminar and field trip

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

Prof. Dr.-Ing. A. E. Tekkaya • 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 „Methods of Virtual Production II“ or „Simulation Methods in Forming Technology II“ discusses the methods of forming process modeling.

- Examples of use (process simulation, component layout)
- State of deformation & state of stress (basics, special cases, von Mises criterion / Tresca criterion, introduction to anisotropism)
- Flow criteria, flow curve, flow rule, parameter identification
- Specification of analytical, semi-analytical, and numerical approaches
- Slip-line theory, upper-bound method, membrane theory
- Thermodynamics in forming

- Introduction to tribology
- Introduction to the Finite-Element-Method (FEM) and Finite-Volume-Method (FVM) with interpretation and applications

Forming Technology III

Prof. Dr.-Ing. A. E. Tekkaya • Dr.-Ing. M. Trompeter
Dipl.-Ing. M. Hermes

Scope 2 L + 1 T
Date summer semester

The lecture „Forming Technology III“ gives a detailed overview of forming machinery. Complex machinery is discussed as well as machine tools. The knowledge about sensors and control systems is broadened. The theoretical background is deepened through seminars and practical examples.

- Machinery and tools
- Sensors and control systems
- Automation
- Modern drive technology, hydraulics

Industrial Lecture Course Industrial Field Reports

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

Scope 2 L
Date winter and summer semester

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

Specialist Laboratory A for Studentsof 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 cupping test and tensile test
- Material characterization by 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 determined. Afterwards, the tests are simulated in order to find out, for example, 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 Laboratory 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 concerning its suitability for forming processes. The tests and the results achieved are then summarized in a scientific report.

Seminars

Following seminar topics were offered in the summer semester 2009 within the scope of the lectures „Forming Technology I“ and „Forming Technology in Industrial Engineering and Management“:

- Subsequent processes of extrusion
- Extrusion materials
- Extrusion history
- Developments in press tooling techniques

- Machines and plants in the periphery of an extrusion press
- Selection of functional elements for composite extrusion
- Analytical investigation of wrinkling in metal spinning processes
- Online and offline strain measurement concepts in forming technology
- Automation in bulk forming
- Automation in sheet metal forming
- Methods planning in forming technology
- Auto bodies for electric cars
- Rapid joining of sheet metal components
- CO^2 reduction through lightweight construction – potentials and limits
- Development of a business plan for the application of telemetric testing facilities
- Forming technology and its historical development
- Global research trends in incremental sheet metal forming
- Special procedures of incremental sheet metal forming

Additional Seminars

- CAD with Catia-V5 for beginners
- Basics und application of GOM measuring systems for 3D digitalization and deformation measurement
- Introduction to the simulation of bulk forming procedures with Deform
- Basics of tensor calculation

Field Trips

- Hannover Messe (Hanover trade fair)

1.3 Completed Diploma Theses

Braun, Daniel
Betreuer Tekkaya, A. E. • Kwiatkowski, L. • Allwood, J.
M.Incremental Sheet Metal Forming with Partially Cut Out Blanks

Echtle , Judith
Betreuer Tekkaya, A. E. • Becker, D. • Pietzka, D.
Untersuchung der Verfahrensintegration Runden beim Strangpressen und Verbundstrangpressen

Hristov, Ivan Vasilev
Betreuer Abel, H.-J. • Hermes, M.
Innovatives Dornkonzept zum deformationsfreien 2D-Biegen von Leichtbauprofilen

Nolting, Stephan
Betreuer Tekkaya, A. E. • Chatti, S.
Konstruktion einer flexiblen querkraftfreien Vorrichtung zur Kennwertermittlung von Blechen

Weddeling, Christian
Betreuer Tekkaya, A. E. • Psyk, V. • Daehn, G.
Shape Calibration of Aluminium Aviation Parts using Electromagnetic Forming

Zumsande, Kathrin
Betreuer Tekkaya, A. E.; Karbasian, H.; Kuhn, P.
Der Einfluss von Aluminium auf die Rissbildung zinkbasierter Überzüge bei der direkten Warmumformung

1.4 Completed Student Theses

Alkas Yonan, Sammer • Steffen, Manuel
Betreuer Tekkaya, A. E. • Kloppenborg, T.
Simulation von Strangpressprozessen

Becker, Jana • Selimbegovic, Elmedina
Betreuer Tekkaya, A. E. • Risch, D.
Wirtschaftlichkeitsbetrachtung der elektromagnetischen Blechumformung

Bell, Katrina • Hoffmann, Daniela
Betreuer Tekkaya, A. E. • Brosius, A. • Gösling, M. • Witulski, J.
Konstruktion eines modularen Tiefziehwerkzeugs

Göhlich, Nadine • Myslicki, Sebastian
Betreuer Tekkaya, A. E. • Güley, V.
Recycling gemischter EN AW-6060, EN AW-6082, EN AW-7075 und Kupfer-Späne durch direktes Strangpressen

Höhling, Ortrun
Betreuer Tekkaya, A.E. • Risch, D.
Analyse des Hochgeschwindigkeitszugversuches an Aluminium-Flachzugproben

Hubert, Alexander
Betreuer Tekkaya, A. E. • Witulski, J. • Crostack, H.-A. Refflinghaus, R.
Ermittlung von Einflussparametern auf den Streifenzugversuch zur Bestimmung von Reibkoeffizienten

Li, Chentao
Betreuer Tekkaya, A. E. • Witulski, J.
Charakterisierung von Thermoplasten hinsichtlich der Eignung als Tiefziehwerkzeuge

Pergande, Michael • Schuster, Philipp
Betreuer Tekkaya, A. E. • Franzen, V. • Kwiatkowski, L.
Wirtschaftlichkeitsvergleich innovativer, inkrementeller Umformverfahren mit konventionellen Verfahren bei der Fertigung eines Scheinwerferreflektors

Loskand, Martin
Betreuer Tekkaya, A. E. • Psyk, V.
Analyse von Einflussparametern auf die Werkstückeigenschaften bei der Fertigung von Bauteilen mit abgeflachter Querschnittsgeometrie mithilfe der elektromagnetischen Kompression

Rödding, Daniel
Betreuer Tekkaya, A. E. • Becker, D.
Numerische Analyse des Rundens beim Strangpressen unter Berücksichtigung externer Einflussfaktoren

Schulz, Philipp
Betreuer Tekkaya, A. E. • Kwiatkowski, L.
Entwicklung einer Aufnahme für Drückwalzwerkzeuge

Schwane, Martin
Betreuer Tekkaya, A. E. • Kwiatkowski, L.
Simulation der Materialumformung beim Einziehen durch Drücken mithilfe der Finite-Elemente-Methode

Sieczkarek, Peter
Betreuer Tekkaya, A. E. • Gösling, M.
Experimentelle Studie von Rückfederungseffekten beim Hutprofilziehen und Ermittlung von Materialkennwerten zu deren Simulation

Sievers, Norman • Lambrecht, Jens
Betreuer Tekkaya, A. E. • Kwiatkowski, L.
Untersuchung des Werkstoffeinflusses und der Halbzeuggeometrie beim Einziehen durch Drücken

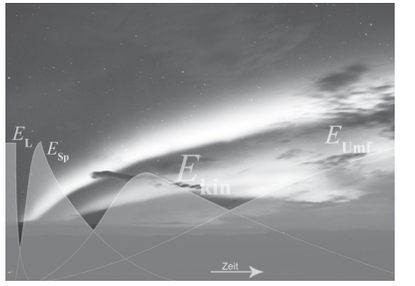
Smajic, Ahmet
Betreuer Tekkaya, A. E. • Gösling, M.
Hutprofilziehen und Ermittlung von Materialkennwerten zu deren Simulation

1.5 Doctoral Theses

Risch, Désirée — **Energy Transfer and Analysis of the Influencing Parameters in Net-Shaping Electromagnetic Sheet Metal Forming**

Series	Dortmunder Umformtechnik
Publisher	Shaker Verlag, Aachen, 2009
Oral examination	April 30th, 2009
Primary advisor	Prof. Dr.-Ing. M. Kleiner
Co-advisors	Prof. Dr.-Ing. A. E. Tekkaya
	Prof. Dr.-Ing. M. Putz

The main aim of the investigations carried out within the scope of this thesis was to establish a detailed process analysis of net shaping electromagnetic sheet metal forming. For this purpose, not only the technological parameters, but also the energetic variables have been considered. Within the process analysis, the significant process parameters are identified and analyzed in order to detect the interdependencies between single parameters as well as the retroactivity on other influencing parameters. On this basis, the energetic relations could be identified subsequently. In this context, the different types of energy could be determined qualitatively as well as quantitatively.
In order to carry out the energy analysis the electromagnetic sheet metal forming process was divided into so-called subsystems. In this way, the occurring energies could be assigned to the different process phases. In order to determine or estimate the amount of energy in each subsystem different methods or evaluation strategies were presented. Finally, the evaluation strategies for each type of energy were applied exemplarily on a spherical as well as on a conical geometry.

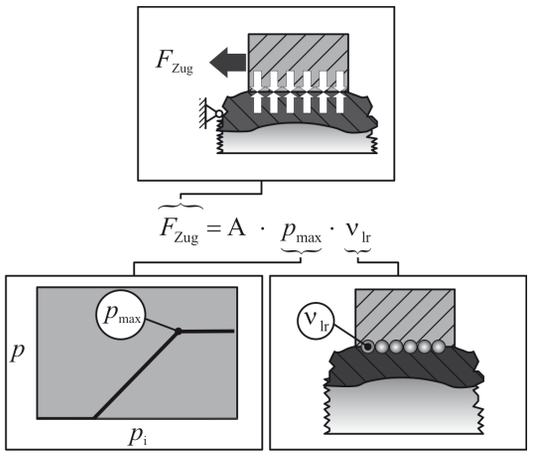


Energy transfer within the electromagnetic sheet metal forming process

Marré, Michael — Fundamentals of Process Design for Joining by Expansion with High-Pressure Media

Series	Dortmunder Umformtechnik
Publisher	Shaker Verlag, Aachen, 2009
Oral examination	Mai 29th, 2009
Primary advisor	Prof. Dr.-Ing. A. E. Tekkaya
Co-advisors	Prof. Dr.-Ing. M. Kleiner
	Prof. Dr.-Ing. V. Schulze

A major trend in manufacturing is the production of highly individualized products. These products have to be manufactured using flexible manufacturing systems to produce high quality products with sufficient process capability. Consequently, the manufacture of single components made of lightweight construction materials and their assembly to form groups must be executed with the required process reliability. The aim of the present work is to present fundamental calculations for the joining by expansion, using the example of dieless hydroforming. The design of joints can be executed taking material characteristics, the geometry of the joining partners, and the working pressure into account. Experimental investigations have been executed using simple joining tools and specially adopted high pressure equipment. Additionally, design rules for a process-adopted joint using mere force-fit or supporting adhesives are represented.

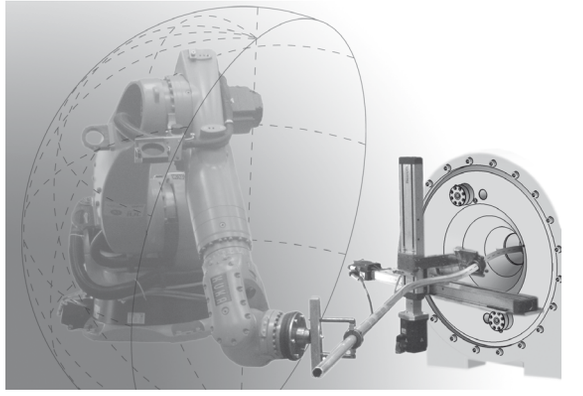


Process design for joining by dieless hydroforming

Becker, Dirk — Extrusion of 3D-Curved Light Metal Profiles

Series	Dortmunder Umformtechnik
Publisher	Shaker Verlag, Aachen, 2009
Oral examination	Mai 29th, 2009
Primary advisor	Prof. Dr.-Ing. M. Kleiner
Co-advisors	Prof. Dr.-Ing. A. E. Tekkaya
	Prof. Dr.-Ing. G. Hirt

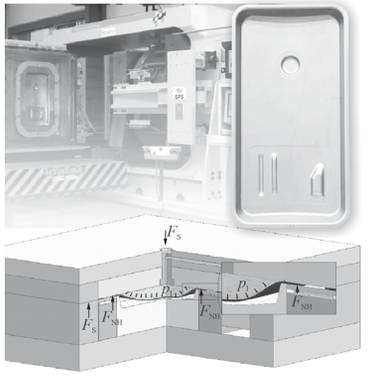
Curved profile extrusion (CPE) for manufacturing 2D-curved aluminum profiles constitutes an alternative method to the conventional process chain which uses bar extrusion and profile bending. The major objective of this work consisted in the advancement of curved profile extrusion for the manufacturing of 3D-curved aluminum profiles with regard to a high contour accuracy. Special emphasis was put on the design and processing of the manufacturing components, which are more complex due to the vertical deflection of the strand, so that the manufacturing restrictions had to be redefined. First, the investigations concentrated on the active principle of CPE which is described by an analytical model of fluid mechanics by means of a superimposed moment. The manufacturing cell was analyzed according to the positioning of the components with regard to the manufacturing accuracy. Within the process analysis by analytical, numerical, and experimental methods the gravity was found to be an essential influencing factor. Finally, the application of CPE for manufacturing curved lightweight profiles was compared to the conventional process chain with respect to profitability.



Flexible Manufacturing Cell for 3D Curved Profile Extrusion

Trompeter, Michael	Hydroforming of Large-area Panels
Oral examination	June 25th, 2009
Primary advisor	Prof. Dr.-Ing. M. Kleiner
Co-advisors	Prof. Dr.-Ing. A. E. Tekkaya
	Prof. Dr.-Ing. H. Hoffmann

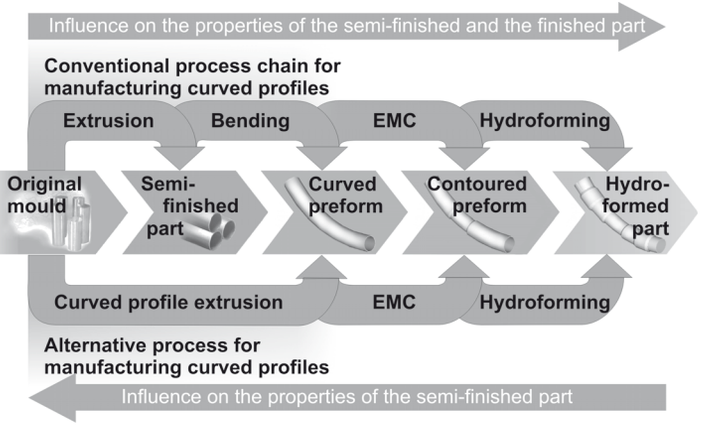
This thesis presents fundamental investigations on hydroforming of large-area panels with local geometry details. For the experimental tests, a 100 MN hydroforming press with integrated 10-point blank-holder system was used. The investigations dealt with volume-based process control, closed-loop process control, tribology, the behavior of the tool system, and the influence of the process setting on the resulting part properties. Tactile online strain measurements proved the impact of the geometric and kinematic tool properties and the blankholder load on the strain distribution. Investigations on the springback behavior of the formed panels could identify bending-unbending effects in combination with a stagnation of tension as cause for springback in the area of the part bottom.
Experimental tests proved that non-linear blankholder load profiles, which pro-vide pure stretching of the sheet metal material during the form base stage, prevent springback in the part bottom and result in a high shape accuracy of the part.



Hydroforming of Large-area Panels

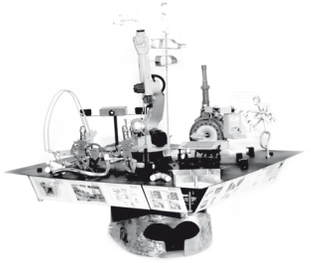
Psyk, Verena	Process Chain Curving - Electromagnetic Compression - Hydroforming of Tubes and Profile-shaped parts
Oral examination	November 23rd, 2009
Primary advisor	Prof. Dr.-Ing. M. Kleiner
Co-advisors	Prof. Dr.-Ing. A. E. Tekkaya
	Prof. Dr.-Ing. K. Roll

Extrusion, hydroforming, and impulse forming processes (e.g. electromagnetic compression – EMC) offer a high potential for realizing lightweight construction strategies, which can be further increased by combining these technologies. In order to do so, a process chain was suggested in which a curved hollow profile is produced and transformed into a contoured preform by EMC before manufacturing the final part by hydroforming.
For the basic analysis of this process chain the semi-finished part was characterized and the influences of its properties and of the parameters of EMC on the preform were investigated. A quantification of the demands to be made on this preform was established on the basis of hydroforming experiments. In a concluding synthesis the technological feasibility of the process chain and the potential for extending the forming limits of conventional hydroforming was proven on the basis of an industrial demonstrator part.



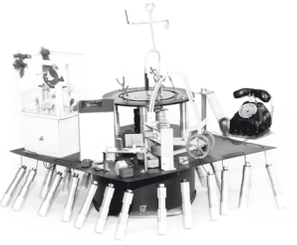
Process chain variants for manufacturing structural parts from hollow profiles

„Doctoral Caps“ 2009



Dirk Becker

Michael Marré



Verena Psyk

Désirée Risch

Michael Trompeter

1.6 Graduate School of Production Engineering and Logistics

The Graduate School of Production Engineering and Logistics is an institution of the federal state North Rhine-Westfalia. It was founded in the winter semester 2000/2001 at the Universität Dortmund in order to advance young scientists. Up to 16 persons receive a scholarship for a period of three years as financial support for their research work. Furthermore, the young scientists participate in an accompanying program which reasonably complements their research activity. The program comprises amongst others: attendance of lectures and professional development courses as well as the submission of interim reports on the progress of the research project. Overall, five departments of the university participate in the Graduate School, each being represented by 2 to 14 chairs.

NRW GRADUATE SCHOOL
OF PRODUCTION ENGINEERING
AND LOGISTICS

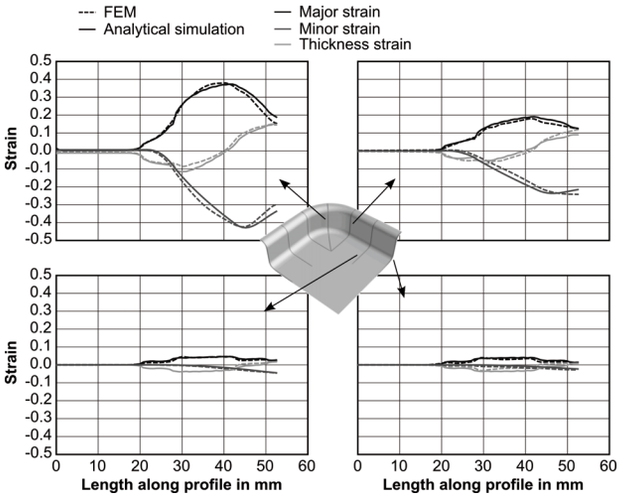
Forschungsschule für
Energieeffiziente Produktion
und Logistik

As from October 1, 2009, the Graduate School of Production Engineering and Logistics was converted into its succeeding model: the Graduate School of Energy Efficient Production and Logistics.
The Graduate School is a collaborative initiative of the scientific and engineering faculties of the Ruhr-Universität Bochum and TU Dortmund within the scope of the superior project “Engineering Unit Ruhr”.

Analytical Simulation of Deep Drawing Processes

Funding Graduate School of Production Engineering and Logistics
Contact Dipl.-Ing. T. Cwiekala

Aim of this project is the development of an accurate simulation method for deep drawing processes which is fast enough to enable an application in online process control systems where existing approaches are either too slow in case of numerical simulation or too inaccurate in case of analytical simulation.
By combining different analytical approaches a method was developed that allows a prediction of strain and stress distributions along section lines of 3D deep drawing parts. This method considers multiple deformation steps, material behavior, and process parameters. Due to its analytical character the developed method is much faster than numerical one-step solvers.
For rotation-symmetric deep drawing processes the simulation method was extended with a graphical user interface and can be downloaded from the IUL homepage.

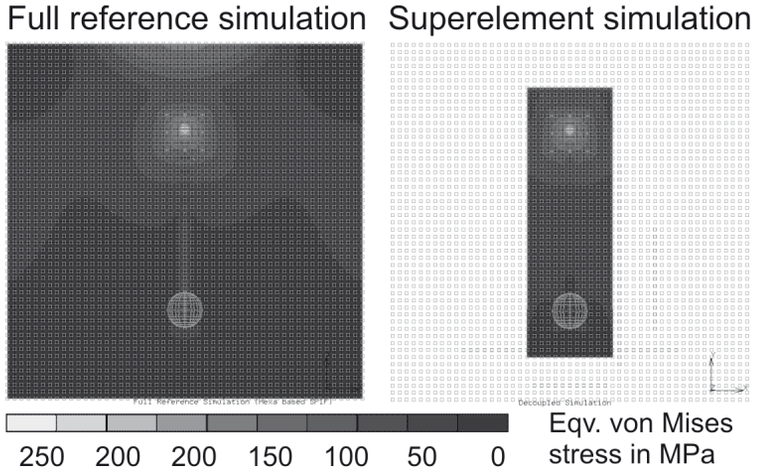


Comparison of strain results between the analytical method and a FEM simulation

Efficient Modeling of Incremental Sheet Forming

Funding Graduate School of Production Engineering and Logistics
Contact M.Sc. G. Sebastiani

The present work aims at providing a time-efficient solution strategy for ISF simulations in commercial software. Denoted strategy comprises a decoupling algorithm [Sebastiani et al. 2007], but focuses on static condensation to reduce the model size. Consequently, this entails a discussion on large deformations; hence, such effects are not covered by the resulting linear superelements.
Incremental forming processes feature a small forming zone on a large elastic blank. Thus, a reduction of the elastic partition will pay off in the computation time required. However, such a model reduction is only valid for certain positions of the plastic forming zone. Taking heed of the tool movement, a frequent update of both, the forming zone and the remaining elastic structure, is inevitable.
This project investigates the implementation of an updating scheme for the use of superelements in AISF simulations. This entails a suitable algorithm and a discussion on speed-up and accuracy.



Von Mises Equivalent Stresses
Left: Full reference simulation, right: Superelement

Influence of Process Parameters on the Product Properties of Sheet Metal Parts Using Organic Coated Sheet Metals

Funding Deutscher Akademischer Austauschdienst
Contact M.Sc. Ha-Duong Pham

The aim of this project is the application of FEM to simulate the industrial forming process of organic coated sheet metals (OCSM) for predicting the change of surface properties such as gloss reduction and color change. In addition, the influence of the process parameters on the product properties is considered in order to optimize the forming process. To achieve the research goals, a combined approach of numerical (FE simulation) and experimental studies is proposed.
The computational results and the validated reference tests of the developed modeling strategy have shown that the simulation results can be used to predict the change of surface quality of the coating layer after forming. Furthermore, the derived relations between strain states, deformed degree, and surface properties are pointed out and considered as a quality criterion for process design.
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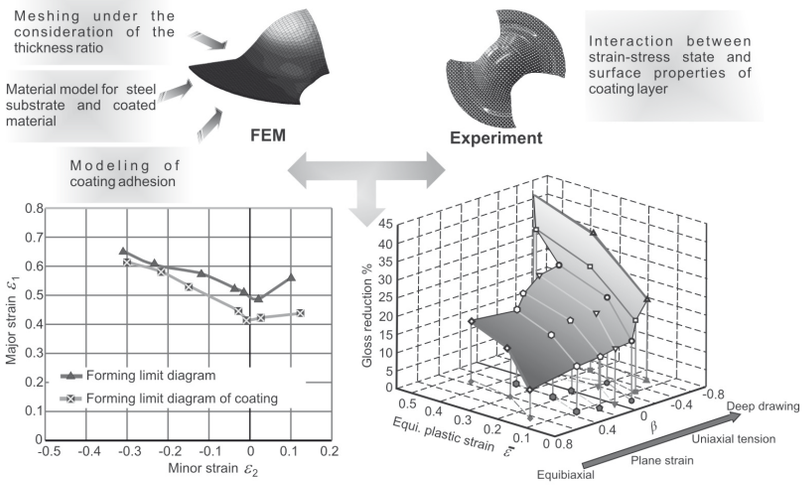


Process design for the forming of organic coated sheet metals

2 Research

The IUL staff includes 45 scientists, research assistants, PhD-students as well as 12 technicians and administrative staff members and 50 student assistants.

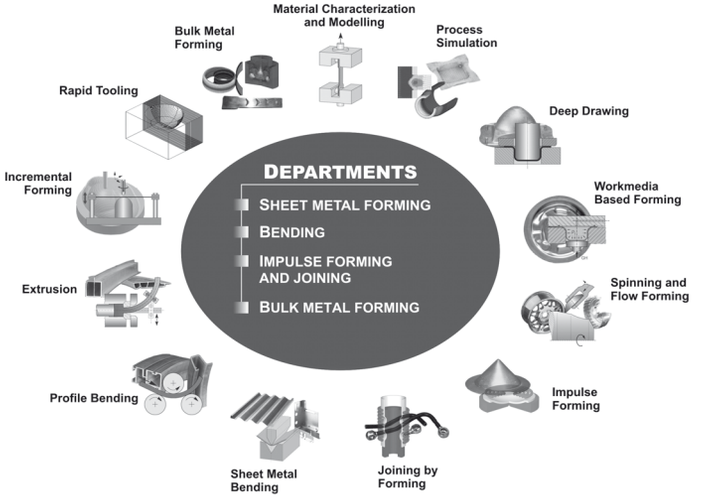
The IUL is divided into four departments:

- Sheet Metal Forming
- Bending
- Impulse Forming and Joining
- Bulk Metal Forming

Two working groups have been established to support the departments:

- Modeling and simulation
- Measurement systems

The research projects are organized in small interdisciplinary teams.



2.1 Overwiev
Sonderforschungsbereich SFB Transregio 10

Spokesman Prof. Dr.-Ing. A. E. Tekkaya
Chief Oper. Officer Dr.-Ing. Dipl.-Wirt.-Ing. M. Marré

The development of scientific fundamentals and methods for the design of integrated process chains for an automated and product-flexible batch production of light space frame structures is the major target of the Collaborative Research Center SFB/Transregio10. Here, the key aspects are in particular:

- Achieving a broad flexibility of the production technology
- Simulating the complete process chain in order to optimize the interlinking of production steps.

The Collaborative Research Center SFB/Transregio10 pursues an exemplary model for the combination of forming, cutting, and joining by implementing an idealized process chain for the flexible production of lightweight structures. This process chain is, in cooperation with the Karlsruhe Institute of Technology (KIT) and Technischen Universität München (TUM), exemplarily put into practice by selected processes implying great potential for the future.

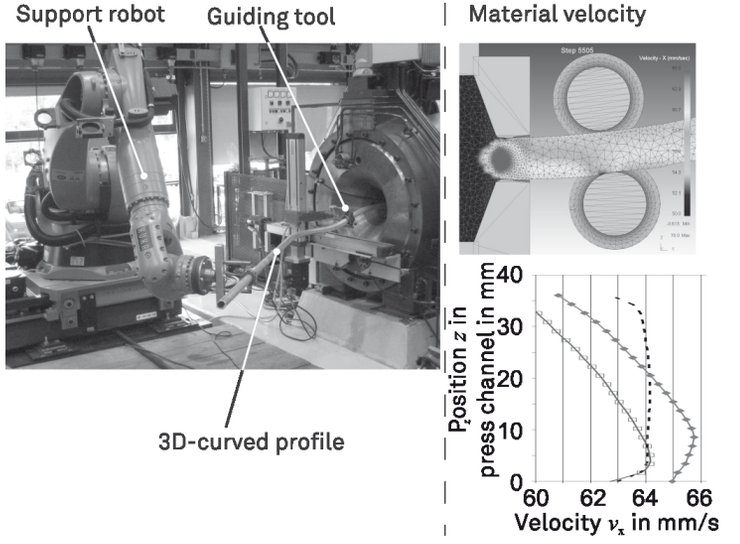
The participating institutes and chairs are:

- IIUL, 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
- iwk I, Institute of Materials Science and Engineering I, KIT – Karlsruhe Institute of Technology
- iwb, Institute for Machine Tools and Industrial Management, TU München

2.2 Multi-Axis Curved Profile Extrusion

Funding German Research Foundation
Project SFB/TR 10 • Subproject A1
Contact Dipl.-Inform. A. Selvaggio
Dr.-Ing. Dipl.-Wirt.-Ing. D. Becker

In this project, as part of the Collaborative Re-search Center SFB/TR 10, the direct manufacturing of curved profiles integrated in a conventional extrusion process by deflecting the strand by a linear axis system is researched. The work focuses on the geometrical accuracy of the curvatures and the integration of process aspects like manufacturing, machining, and handling.
The investigations of the influencing factors (i.e. gravity) carried out in the first funding period will be further expanded supported by FEM simulations. For example, the profile support against gravity influence is applied by a six-axis robot system, which is necessary due to the three-dimensionally curved profile contours.

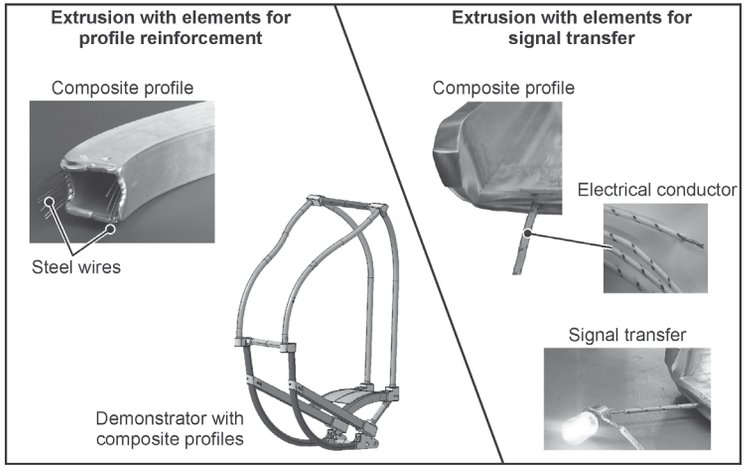


3D-curved profile extrusion and FEM-simulation of the influenced material flow

2.3 Composite Extrusion

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

The project “composite extrusion” deals with the manufacture of endless reinforced compound profiles for structural lightweight applications. As reinforcement high-strength metallic or non-metallic wires or tapes are used. The elements are embedded in a common aluminum or magnesium alloy by the extrusion process. The extrusion process allows the production of profiles with a large variety of different profile cross-sections.
The combination of a lightweight material with an embedded high-strength component can improve the mechanical behavior of the structure concerning strength and stiffness significantly. In addition to the improvement of the mechanical properties of profiles, functional elements like isolated electrical conductors could be embedded in profiles to extend the potential for lightweight applications. Profiles with integrated functional elements offer the potential for signal or data transfer or structural monitoring.

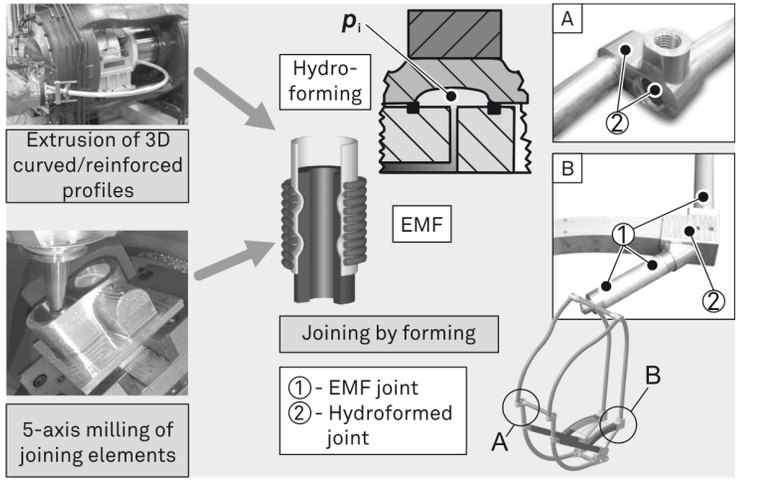


Composite profiles with different types of embedded elements

2.4 Joining by Forming

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

Within this project the procedure of joining by forming shall be integrated in a flexible process chain that allows the manufacturing of lightweight frame structures. Based on fundamental technological investigations alternative joining strategies for reinforced and non-reinforced extruded profiles are being developed. The results of these investigations will also be used to create general design principles for the joining process itself as well as for the joining zone.
The joining processes which are considered within this project are joining by expansion through hydroforming and joining by compression using electromagnetic forming (EMF). For an optimal integration of these joining processes in the process chain it is important to analyze the potential influence of previous manufacturing steps, like extrusion and machining of the profiles, on the joint characteristics. To prove the applicability of both processes in a flexible process chain a joining station was designed and built. It is part of the prototype production line of the SFB/TR10.

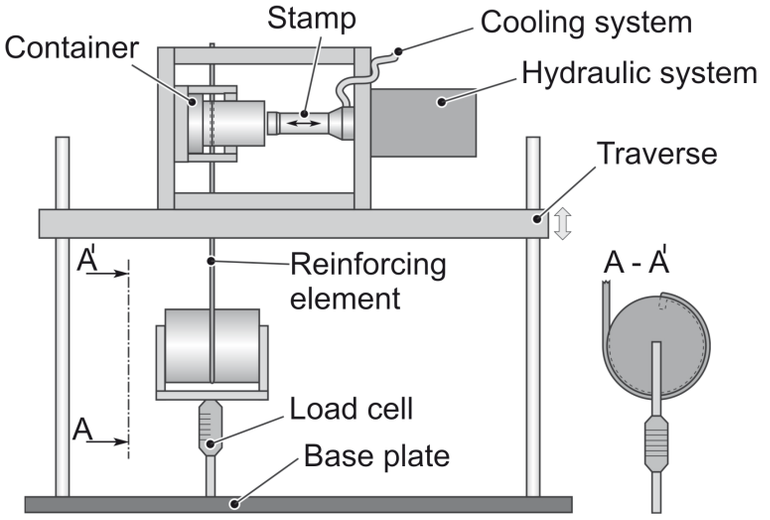


Principle process chain for joining by forming using hydroforming or electromagnetic forming (EMF)

2.5 Simulation of Composite Extrusion Processes

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

The project deals with the analysis of the composite extrusion process within the scope of the Collaborative Research Center SFB/TR 10, funded by the German Research Foundation. A small-scale test was build up for the quantification of the process determining parameters in composite extrusion processes. Thus, the conditions inside the welding chamber can be simulated to analyze the characteristic parameters for a process-reliable embedding of the reinforcing elements (RE). During the experiments a container is filled with aluminum and preheated to welding chamber temperature.
A hydraulic system is then used to induce the hydrostatic pressure stress onto the aluminum base material. By pulling out an inserted reinforcing element the shear stress, which effects the RE in the real process and which often causes RE failure, can be calculated close to reality.

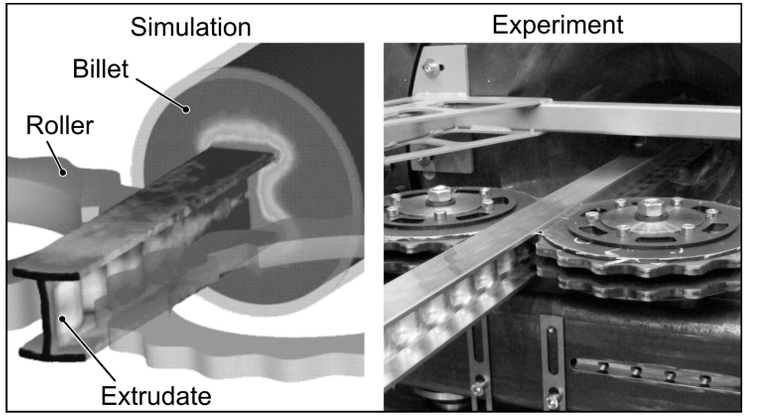


Small-scale test for the quantification of the process determining parameters in composite extrusion processes

2.6 Thermo-mechanical 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, in connection with the resulting microstructure, profiles with specifically adjusted properties can be manufactured.
High ductility and temperature of the semi-finished product are used in order to manufacture functionally graded, complex structural parts, based on the aluminum extrusion technology. For the thermo-mechanical processing of hollow sections a combined process of extrusion and electromagnetic compression was invented (q.v. page 67).
Considering processing of open sectioned profiles, an integrated rolling process was developed. Experimental investigations of the processes under consideration were assisted by numerical analyses in order to determine the significant process parameters, such as the state variables during extrusion and the subsequent forming operations, e.g. the electromagnetic compression as well as the material flow.

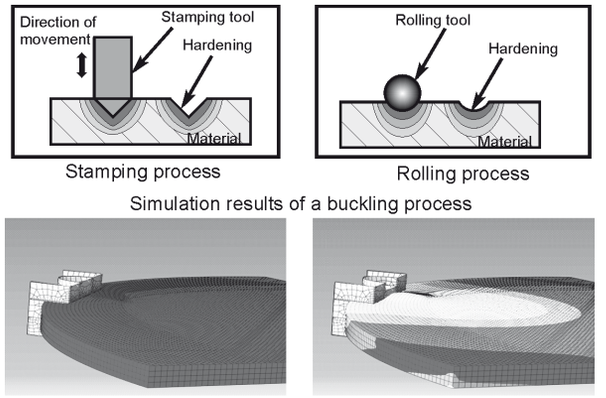


Combined process of extrusion and rolling

2.7 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. S. Schunck

The aim of this project is the development of a novel procedure by which load-otimized parts can be produced. For this purpose, cold massive forming methods, as e.g. stamping and rolling, are used. On the one hand, the processes of stamping and rolling (which are shown in the graphic) should lead to a certain material flow and on the other hand the processes should result in in a cold hardening effect. By appropriately combing the processes an accurate definition of these parameters for a wide range of applications might be achieved. Moreover the particular accuracy shall enable calibration processes of preformed part structures.
The focus of this project is on the forming of secondary form elements, like e.g. sprocket structures. Therefore, an investigation of the different processes focusing on the corresponding forces and demands on the machines as well as of the possible precise adjustment of the material flow and of the hardening effect needs to be carried out. Furthermore, the combination of the processes shall be investigated in more detail.

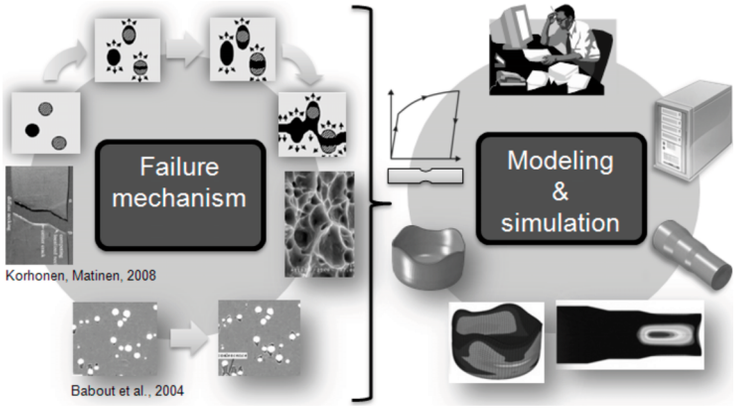


Procedures of massive sheet metal forming

2.8 Analysis of Strain-path Dependent Damage and Microstructure Development for the Numerical Design of Bulk-sheet Metal Forming Processes

Funding	German Research Foundation
Project	SFB/TR 73 • Teilprojekt C4
Contact	PhD. C. Soyarslan

The aim of this study is an experimental and numerical analysis of the microstructure development during sheet-bulk metal forming in connection with material deterioration. In experimental terms, the mechanisms leading to void nucleation, growth and coalescence are being investigated by micromechanical observations and mechanical parameter identification tests are being realized. In numerical terms, a framework for finite strain anisotropic plasticity is being developed, taking damage coupling into account. For this purpose, user defined material subroutines are being developed by implementing established phenomenological (Lemaitre) and micromechanical (Gurson) damage models.
The implemented models, which are appropriately regularized for softening, will be used for parameter identification studies by inverse methods. The outcomes will be used to develop a database which includes the quantitative formability limits in bulk-sheet forming processes to assist the selection of the workpiece materials in actual applications..



Summary of the research topics

2.9 Analysis and Optimization of Complex Forming Processes by Means of Statistical Design of Experiments Using the Example of a CNC-controlled Spinning Process

Funding	German Research Foundation
Project	SFB 475 • Subproject C6
Contact	Dipl.-Ing. L. Kwiatkowski

Within the Collaborative Research Center SFB 475 this project deals with a multivariate optimization of the spinning process. In collaboration with the statistics department of the Technische Universität Dortmund an iterative and sequential generation of experimental designs was developed. The geometrical complexity of the workpieces was increased stepwise.
Furthermore, the investigations focused on high strength and thin materials. Individual process windows were developed as a result. They particularly show the influence of the process parameters on the process limits. To characterize the process a new parametric approach for describing the tool motion has been developed. It allows designing the tool motion completely as a function.
Hence, an explicit and reproducible description of the process is possible. This is an essential factor especially for the optimization of parts.
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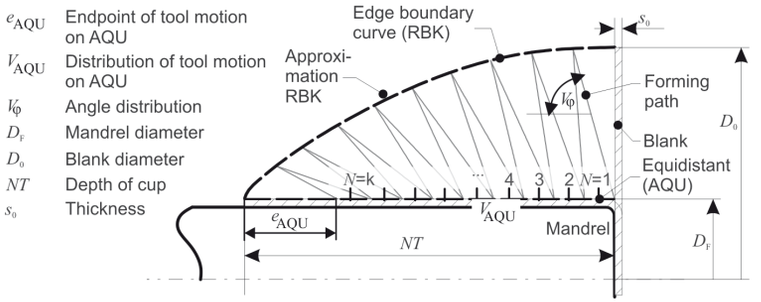
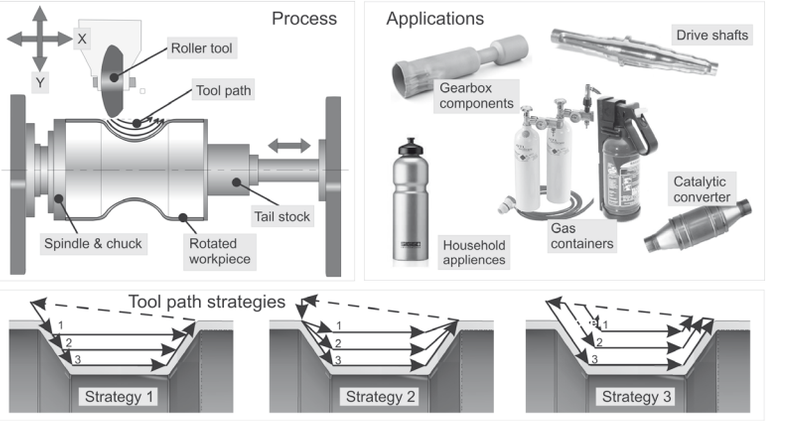


Parametric tool motion for spinning

2.10 Application of Statistical Methods for Process Design and Optimization in Necking-in Processes

Funding	German Research Foundation
Project	SFB 475 • Subproject T2
Contact	Dipl.-Ing. L. Kwiatkowski

The transfer project T2 within the Collaborative Research Center SFB 475 investigates in collaboration with the faculty of statistics the character of the incremental necking-in process.
The initial point is the transferability and adaptation of the developed statistical methods of project C6. The investigations are carried out in collaboration with the industry partners Volkswagen, Mannesmann Präzisrohr, Benteler, WF Maschinenbau, and Winkelmann Dynaform.
The results are based on a mainly experimental investigation of different forming cycles, which are known as tool path strategies.
The developed statistical process model allows a prediction of the considered quality features, as e.g. surface quality, material thickness distribution, or process time. In dependency of the desired part properties a set up of a target-oriented process design is possible.
The utilization of the developed optimizing procedure allows a further increase of the part quality.

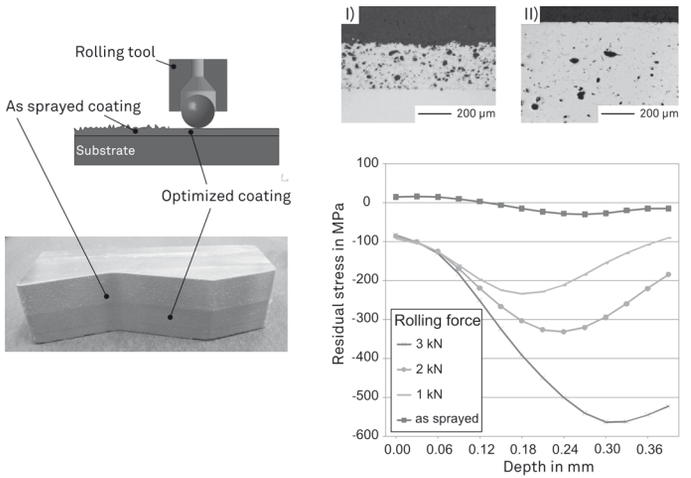


Incremental necking-in: Process design, tool path strategies, and applications

2.11 Optimization of Thermally Sprayed Surface Coatings by Incremental Roller Burnishing

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

The objective of this project is the subsequent processing of thermally sprayed coatings for the application in deep drawing tools by incremental roller burnishing (see Fig.). The coatings are optimized to meet the tribological demands in forming operations of high strength sheet materials. Thermally sprayed coatings, containing hart materials, provide high wear resistance, but are rough and porous after spraying and, therefore, require a post treatment in order to smooth and densify the coating. This is realized by incremental roller burnishing, which not only reduces the roughness at the surface and densifies the coating but also allows a texturing of the coated surface.
The incremental process strategy provides a very flexible surface processing. This allows a specified adjustment of the tribological surface properties in order to realize a defined material flow during the forming process. Furthermore, by the plastic deformation of the coating during the rolling process residual compressive stresses in the surface layer are generated, which significantly reduces the risk of surface cracks.

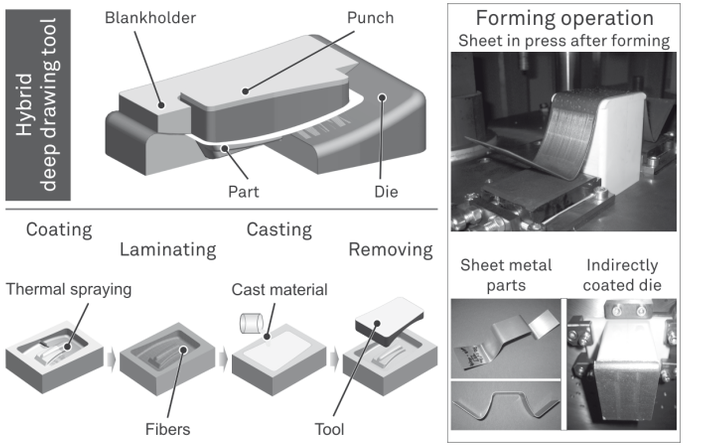


Optimization of coated surfaces by incremental roller burnishing

2.12 Development of a Hybrid Deep Drawing Tool Using Locally Structured Surfaces

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

In this subproject of the Collaborative Research Centre Program SFB708, the development of a rapidly producible and cost-effective hybrid deep drawing tool of a high wear resistance for the production of sheet metal parts in small to medium batch sizes is investigated. For this purpose, hard material is thermally sprayed on a negative mould and supported by a polymer which is reinforced by aramid and carbon fibers. The bonded laminate and coating are removed and act as one part of the tool.
The friction behavior of the indirectly coated surfaces is similar to the one of conventional deep drawing tools. The wear resistance is high enough to form mild steels as well as high strength steels.
Compression tests with hybrid tools show the possibility to adapt the tool stiffness by the use of reinforcement fibers. The results indicate that these hybrid deep drawing tools are promising alternatives to conventional deep drawing tools.

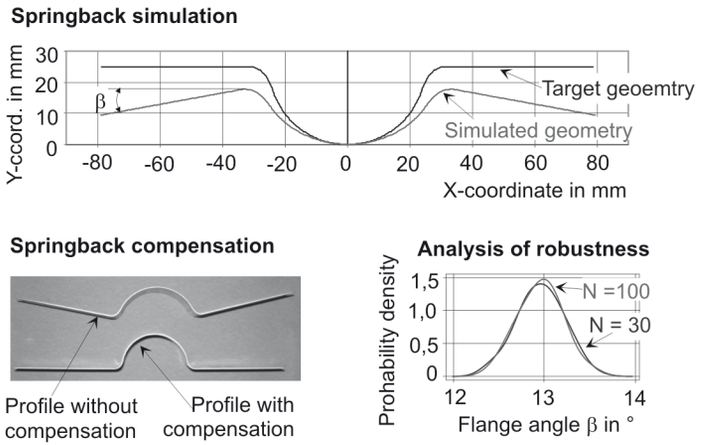


Process chain for manufacturing the hybrid deep drawing tool and forming results

2.13 Strategies for the Compensation of Springback-related Form Deviations

Funding	German Research Foundation
Project	SFB 708 • Subproject C3
Contact	Dipl.-Ing. M. Gösling

The SFB 708 aims at the implementation of wear resistant coatings on complex deep drawing tool surfaces by means of thermal spraying.
One disadvantage of this approach is that modifications of the coated tools, which become necessary due to springback effects, are quite limited. Hence, the aim of subproject C3 is the numerical compensation of form deviations in sheet metal forming caused by springback.
In a first step, the accuracy of springback predictions by means of FEM was analyzed. The investigations showed that a good accuracy is possible by applying an adequate material model.
In a second step, the studies also covered the compensation of springback. Here, special focus is put on a springback compensation with regard to process robustness. One task is the reduction of the numerical effort in comparison to existing approaches.

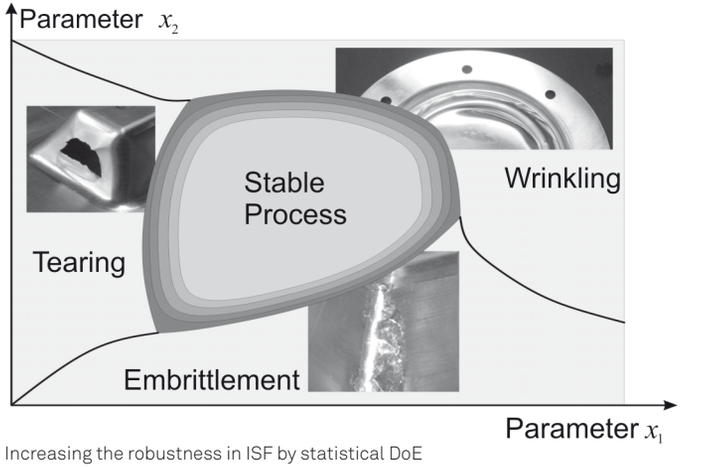


Simulation and compensation of springback

2.14 On Dynamic Process Properties of Kinematic Incremental Sheet Forming

Funding	German Research Foundation
Project	SFB 823 • Subproject B2
Contact	M.Sc. G. Sebastiani

In the given project an extensive investigation of Kinematic Incremental Sheet Forming (KISF) is conducted, based on statistical analyses. This highly flexible process of KISF is suitable for the efficient production of parts in small batches or prototypes. However, concurrent process-layouting is a matter of what experts call „undocumented tribal knowledge“.
As superordinate question is to be examined how the process parameters and the physical effect principles can be theoretically related to the process outcome. Within the first project phase it needs to be identified on which cause-effect relations the process is grounded. This is done in scientific co-operation via statistic, experimental, and numerical investigations, performed within an interdisciplinary cooperation of the department of Statistics and the IUL. The superordinate aim of the project is a process model yielding a general physical description of the process.
The superordinate aim of the project is a process model yielding a general physical decription of the process.

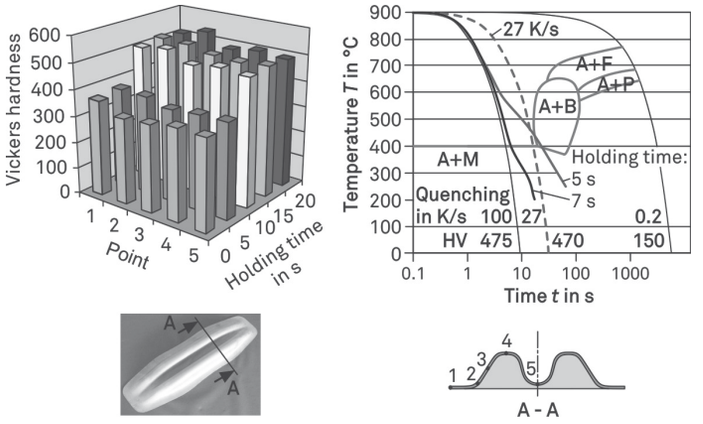


Increasing the robustness in ISF by statistical DoE

2.15 Process Design of Hot Sheet Metal Forming

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

Hot stamping is a thermo-mechanical forming process with intended phase transformation. Depending on the temperature history and mechanical deformation, different phases and phase mixtures evolve. During the solid-state phase transformations heat is released, which influences the thermal field. Furthermore, depending on the mixture of micro constituents, both the mechanical and thermal properties vary with temperature and deformation.
Consequently, a realistic FE model for process simulation must consider the interaction between mechanical, thermal, and microstructural fields. This can only be achieved by means of process characteristics like heat transfer coefficient, material flow behavior, and phase transformation under process-relevant conditions.
The aim of this project is the modeling of final properties, such as shape accuracy and tensile strength within the process simulation, which considers the microstructural evolution.

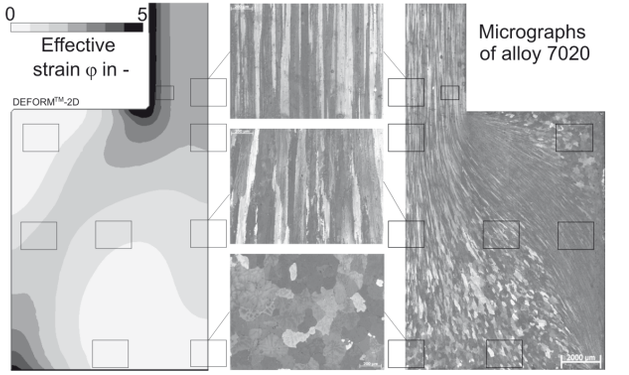


Hardness and simulated cooling rates at different holding times

2.16 Microstructure Evolution during Extrusion

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

The IUL is member of the DFG research group “extrusion” together with the institutes IW and IFUM of University Hannover and the LWT of University Rostock. The investigation in this subproject is about the evolution of the morphology of grains during extrusion which depends on temperature, strain, and strain rate. Therefore, process parameters like temperature, extrusion ratio, velocity, and die shape have an indirect influence on recrystallization and also on the distribution of the precipitations in the aluminum extrudate.
The two different aluminum alloys EN AW-6082 und EN AW-7020 are subjects to investigations in order to determine the influence of every single process parameter on the grain morphology. The grain size can be measured by means of a reference test. State variables are determined by finite element simulations. Utilization of the point tracking of the numerical results and the flow net method enables to find a relationship between grain size and state variables. This relationship is implemented in a FE code to calculate the grain morphology and to systematically adjust the behavior of the product.

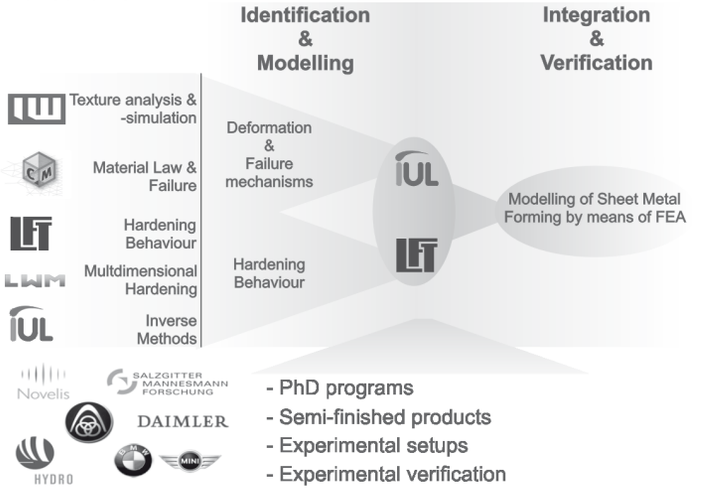


Example for linking experimental and numerical results with the alloy EN AW-7020

2.17 Identification and Modeling of Material Behavior for the Finite-Element Analysis of Sheet Metal Forming Processes

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

The purpose of this research project is the improvement of methods suitable for determining the material behavior in sheet metal forming processes as well as the identification of theoretical models used in this context and the parameters involved. The major motivation fostering the research activities is an improvement of the quality of numerical process simulations using the finite-element method as today's modern materials involve a clear deficit due to unconsidered effects in numerical modeling procedures. Within the scope of this project researchers from Dortmund, Hanover, Erlangen, and Chemnitz cooperate in the field of manufacturing technologies, mechanics, materials engineering, and material testing. Special focus is put on an active cooperation of researchers from the industrial sector. A central aspect of the research activities is, besides the identification of material characteristics, the development of new experimental, analytical, and numerical strategies for the evaluation and specification of the material behavior.

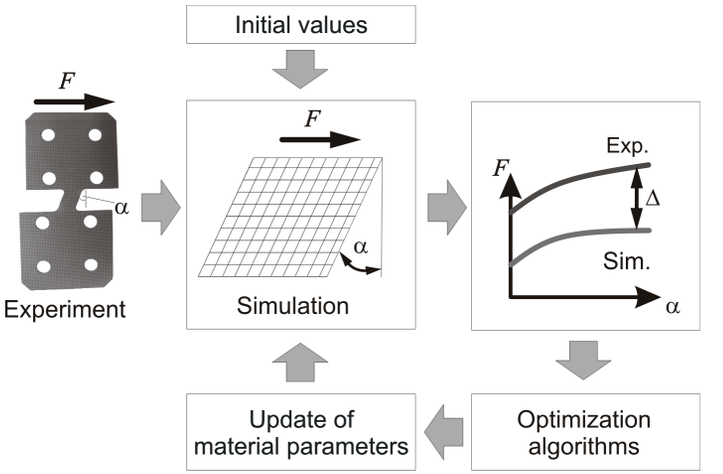


Cooperation, tasks, and industrial consortium

2.18 Identification of Material and Friction Models as well as Corresponding Parameters by Means of the Inverse Method

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

Within the scope of the inverse parameter identification for material models, this project deals with the implementation of optimization algorithms and the analysis of existing and new types of experimental setups for the plastic material behavior.
As an essential step to the final aim, an algorithm is developed, that realizes the coupling between the FE computation and the optical measurement system. By the utilization of the inhomogeneous distribution of the deformation, material parameters needed for the yield criteria are determined, in order to characterize the anisotropic materials. In this context, different experiments are analyzed to obtain the yield locus curve for different states of stresses, such as the notched tensile test or plane torsion test. Especially for the plane torsion test, new evaluation strategies and modifications are developed in the context of the project.

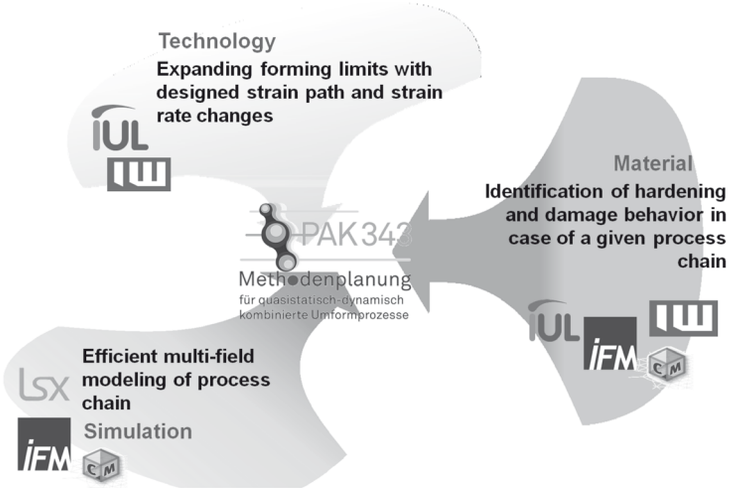


Material characterization by means of inverse finite element analysis

2.19 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

In order to generate a suitable approach for the production of predefined workpiece geometries a methodology for process chains consisting of quasistatic and dynamic forming processes is being developed. In this context tubular workpieces as well as semi-finished parts of sheet metal are considered. The analyzed process chains cover a deep drawing process with integrated electromagnetic sheet metal forming and an electromagnetic compression with a subsequent hydroforming step. An extension of the forming limits will be achieved by combining these different forming operations. Here, the focus is put on the analysis of forming mechanisms at different loading conditions, including the acting work hardening and fracture effects as well.
Thus, fundamental knowledge about the interaction of process parameters during the process duration will be established. This shall be the basis for an efficient methodology for process chains with distinctive changes in strain rates and loading paths.

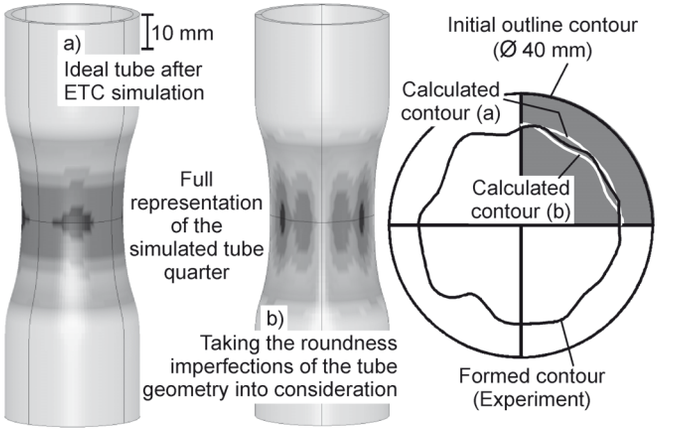


Cooperation between the project partners

2.20 Process Development for Combined Conventional and Electromagnetic Forming Operations

Funding German Research Foundation
Project PAK 343 • Subproject 1
Contact Dr.-Ing. V. Psyk • M.Sc. K. Demir

The aim is the development of a suitable methodology for process chains consisting of quasi-static and dynamic forming operations. The methodology should be able to generate a suitable procedure to manufacture a desired product, which cannot be produced utilizing conventional methods.
The combination of different processes causes a variation of strain path and strain rate during forming. Experimental and numerical investigations are being performed in order to comprehend the effects of this variation upon the forming results. Using these findings, the methodology to be developed should benefit from these effects in order to extend the forming limits.
One of the examined process chains is the electromagnetic tube compression (ETC) followed by tube hydroforming (TH). ETC induces wrinkles, which must be ironed by TH. The intent is to be able to simulate the formation and straightening of the wrinkles to optimize process parameters. Results of wrinkle formation simulations are given in the figure.

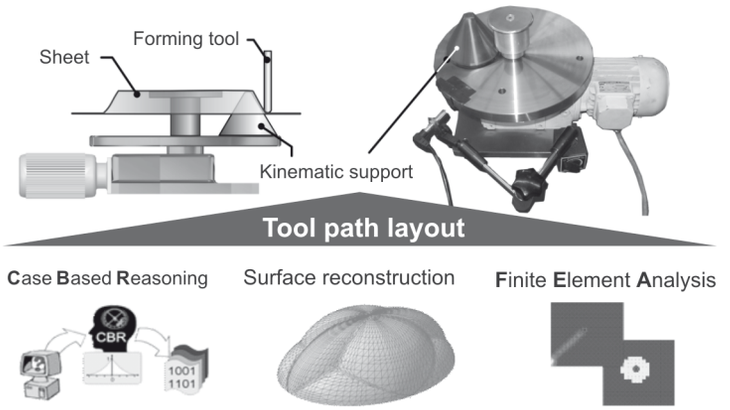


Comparison between the calculated and measured wrinkles at ETC

2.21 Modeling of Kinematic Incremental Sheet Forming

Funding	German Research Foundation
Project	SPP 1146 • TE 508/2-3 (formerly: KL 619/21-1/2)
Contact	M.Sc. G. Sebastiani

As far as kinematic incremental sheet forming (KISF) is concerned, its process layout is a matter of expensive trials. Further on numerical process planning is, due to huge computation times, not feasible. Consequently, a process model is required, providing novice users with a feasible process layout, requiring a minimum number of initial try-outs.
The work presented addresses all these requirements within an holistic process layout environment. First, a technological process model provides a general process set-up for a given task. This set-up is obtained from a set of known, similar solutions, by means of Case-Based-Reasoning (CBR). Next, this set-up is refined by an optimized tool path, thus requiring the boundary surface for the tool path generation to be reconstructed. In order to test the obtained process layout, numerical experiments using FEA are employed, thus requiring modelling strategies for speeding up the simulation.

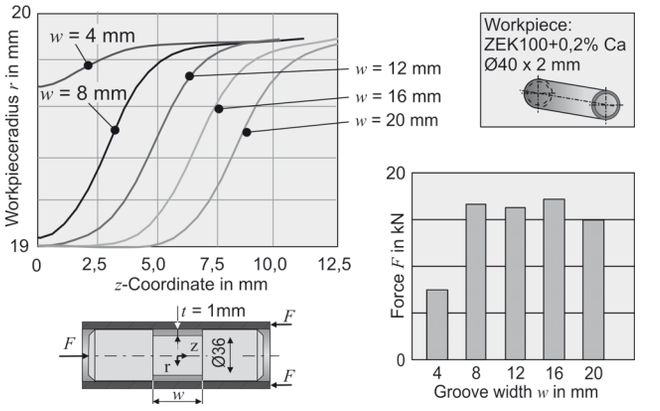


Elementes of the process layout environment for Kinematic Incremental Sheet Forming

2.22 Property Changes of Magnesium Wrought Alloys for Hybrid Joining of Extruded Hollow Profiles by Micro-alloying

Funding	German Research Foundation
Project	SPP 1168
Contact	Dr.-Ing. Verena Psyk
	Dr.-Ing. Dipl.-Wirt.-Ing. D. Becker

During electromagnetic compression (EMC) pulsed magnetic fields are used to realize a diameter reduction of electrically highly conductive tubes due to Lorentz forces. The applicability of this process for force-fit and form-fit joining of extruded magnesium hollow profiles is being investigated in cooperation with the Institute of Material Science of the Leibniz Universität Hannover.
During the analysis of form-fit joints a detailed parameter study considering the influence of the groove geometry was carried out using the example of rectangular grooves. Here, tubes with round and square cross section geometries were regarded. The varied parameters were groove width, groove depth, and the radius of the groove edge as well as the material of the mandrel and the tube. It turned out that the gradient of the workpiece radius in the area formed into the groove is decisive for the transferable force under axial compression load.

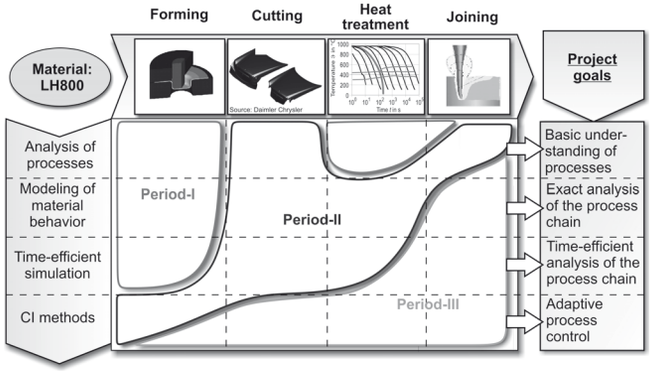


Influence of the groove width on the geometry and strength of the joint

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

Funding	German Research Foundation
Project	SPP 1204
Contact	Dipl.-Ing. T. Cwiekala

This project deals with the fast and continuous modeling and calculation of manufacturing processes of sheet metal parts. In this context, the simulation of the process chain deep drawing – cutting – heat treatment – thermal joining is analyzed for steel LH800. The project aims at obtaining a calculation time which enables an online closed-loop control of the manufacturing process.
Within this project the IUL developed an analytical simulation method for deep drawing processes which enables a very fast and accurate simulation of rotation-symmetric and prismatic parts considering material behavior and deformation history. The calculation of spring-back after deep drawing and cutting is currently being included into the fast simulation method by combining it with a linear elastic finite element simulation.
The simulation of part deformation by thermal effects occurring in the heat treatment and joining process is intended to be developed in the next three years of this project's duration.



Project structure and goals

2.24 Overview
Research Training Group (Graduiertenkolleg) 1378 Manufacturing, Machining and Qualification of Hybrid Material Systems

The Research Training Group (Graduiertenkolleg) 1378 is a university training programme established to focus on hybrid material systems. The primary goal of the research training group is to investigate „manufacturing, machining, and qualification of hybrid material systems". The training group´s approach is to utilize available individual experience in order to advance the development of hybrid material systems. Besides the research part, the study part is also a core of the research training group.
It is designed to communicate basic and interdisciplinary knowledge. International symposia, excursions, soft skill enhancement as well as a program for visiting professors are part of the study program.
The initiators from the departments of materials science, forming and production technology of the universities of Hanover and Dortmund have teamed up as a group in order to properly engage this task. Under this framework, IUL focuses on manufacturing plastic metal hybrid structures.
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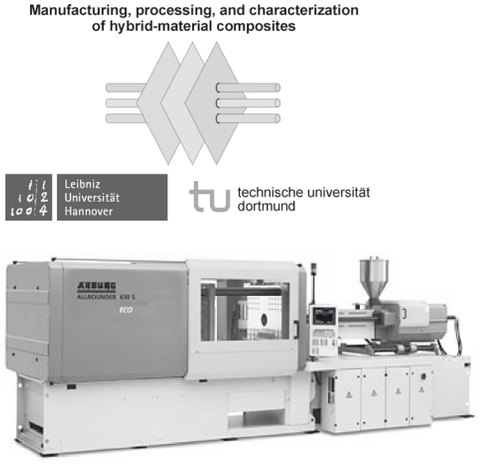
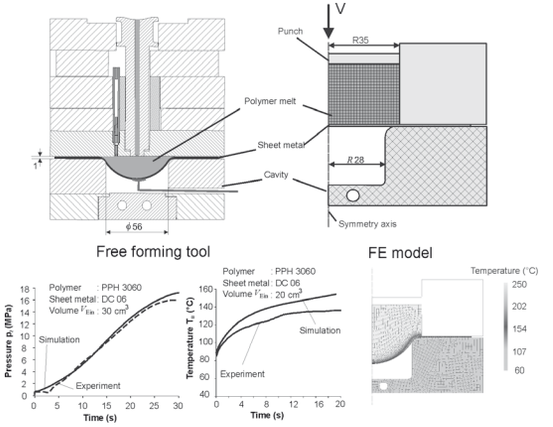


Symbol of GRK 1378 and injection moulding machine installed at the IUL

2.25 Innovative Manufacturing of Hybrid Plastic Metal Structures

Funding	Research Training Group (Graduiertenkolleg)
Project	1378/1/Subproject 9 -Part I
Contact	M.Sc. M. M.Hussain

The established practices for the manufacturing of plastic-metal hybrid structures are limited to injecting plastic over the finished metal insert. The combination of injection moulding and hydroforming, implicating that melted plastic additionally serves as a working medium, opens entirely new design possibilities.
The aim of this work is to develop the basis for the exploitation of the potential associated with the combination of plastic processing and working media based forming technologies. The process fundamentals are to be discovered through numerical and experimental findings. For this propose, a numerical model has to be developed which shall be able to solve the problem of polymer flow and sheet metal deformation. In particular, it should be able to calculate the coupled response of both objects. Besides solving the mechanical part of the problem, the model should be capable of solving the parallel heat transfer problem and its influence on the properties of polymer melt and sheet metal. The validation of the numerical model is to be performed by experimental observations. The particular focus of this work remains on identifying those parameters which influence the formability of the sheet metal blank.

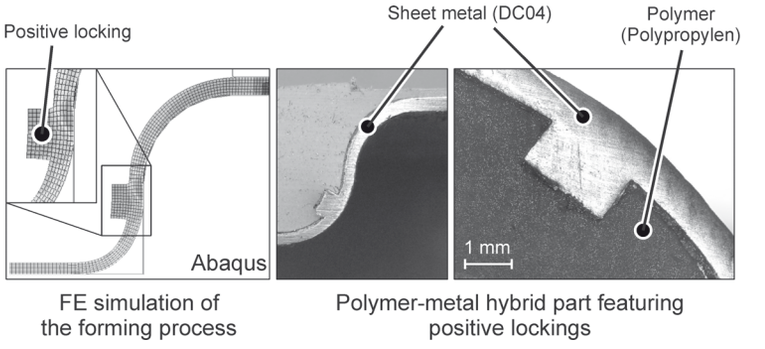


Experimental and numerical investigation of the combined process

2.26 Manufacturing of Innovative Polymer-metal Hybrid Parts

Funding	Research Training Group (Graduiertenkolleg)
Project	1378/1/Subproject 9 -Part II
Contact	Dipl.-Ing. B. Rauscher

Within the framework of this project, the process integration of injection molding and hydroforming is fundamentally investigated regarding the production high-strength metal-plastic composite parts. A key function of this manufacturing concept features the plastic component of the hybrid part, which acts.
as working medium during the forming process plus providing a stiffening structural component of the hybrid part.
The joining of metal and plastic components through positive lockings allows to manufacture mechanically highly loadable hybrid plastic-metal-structures. Within the framework of this project, different kinds of positive locking variants, like e.g. cuttings in the sheet metal or undercuts by structured surfaces of the sheet metal, are fundamentally examined.
In order to achieve high tensile strength as well as high torsional strength the influence of material and geometry of the hybrid components is examined as well as the process parameters regarding the injection molding process.

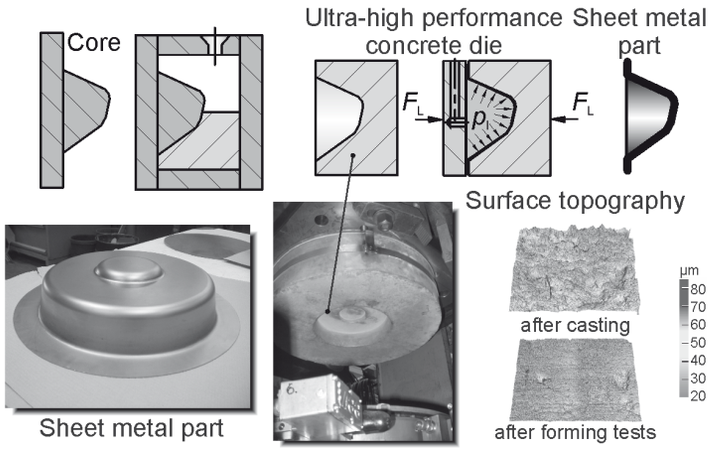


Manufacturing of polymer-metal hybrid parts applying positive lockings
(FE model and microsection)

2.27 Development of Concrete Dies for Sheet Metal Hydroforming

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

The aim of this research project is the development and investigation of ultra-high performance concrete dies for sheet metal hydroforming. In an interdisciplinary collaboration between the Institute of Concrete Structures of the Technical University of Dresden and IUL, the recipe and reinforcement for concrete hydroforming tool systems are developed and optimized regarding the hydrostatic load and the tribological requirements of the sheet metal hydroforming process.
In the course of the project, different tooling concepts could be realized und the casted concrete dies could be successfully used for sheet hydroforming up to high forming pressures. Current investigations deal with the influence of pre-loading on the performance and with the optimization of the tribological system of the concrete dies.
The gained knowledge will establish a novel methodology for the material-adapted design of forming tools made of ultra-high performance concrete.

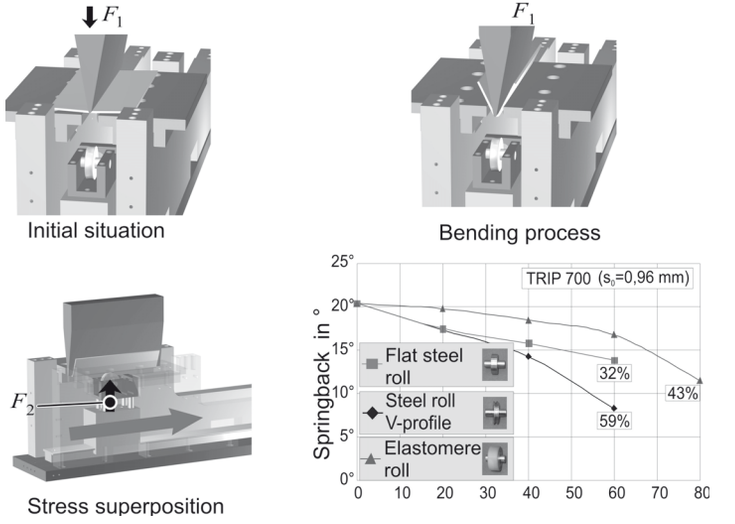


Process chain for a fast and economic manufacture of sheet metal parts using dies made of ultra-high performance concrete

2.28 Study of Springback Compensation in Sheet Metal Bending Using Compression Stress Superposition

Funding	German Research Foundation
Project	MA 1883
Contact	Dipl.-Ing. A. Weinrich

The aim of this project is the theoretical and experimental examination of springback compensation, using the example of a new and flexible method of sheet metal bending. The principle of this new method is based on the incremental superposition of compression stresses in the forming zone.
First of all, the the investigation will focus on the influence of different parameters like the geometry and material of the roll. In this way an analysis could be done. With the aim of finding the correlation between the used process parameters and the springback.
The stress state inside the metal sheet changes with the load of the roll. FE simulations will be performed, in order to find the relationship between the parameters used. Experimental tests will be carried out to verify the simulations.

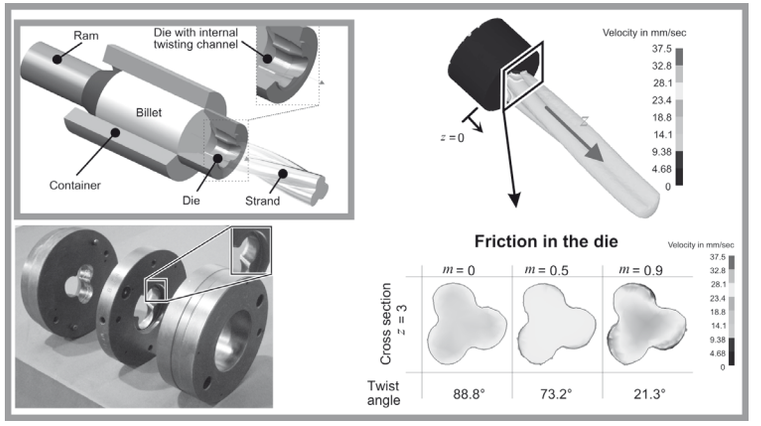


Principle of the compression stress superposition and experimental results

2.29 Alternative Paths for the Manufacture of Screw Rotors by Forming

Funding	German Research Foundation
Project	TE 508/3-3
Contact	Dipl.-Ing. N. Ben Khalifa

The aim of the joint project with the Chair of Fluidics of the Technische Universität Dortmund is the investigation of the interaction between manufacturing methods and component properties of screw rotors.
For this purpose, two innovative extrusion processes are developed and investigated: Twist Profile Extrusion (TPE) and Helical Profile Extrusion (HPE).
In the current project period the die design for HPE could be optimized by means of finite element analyses, so that the higher twist angle and the contour accuracy could be significantly improve and, thus, the efficiency of the screw rotors can be increased.
The torque of the guiding tool during TPE was investigated by means of FEM. It turned out that, due a superposition of the external torsion process with the extrusion process, the torque could be reduced by approximately 50% compared to hot torsion tests without extrusion, which emphasizes the energy efficiency of this method.

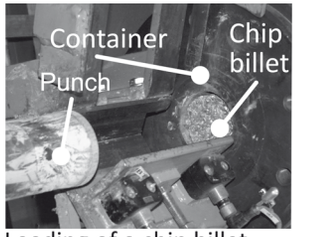


Twist Profile Extrusion (TPE):
process principle, die design, and FE simulations of the material flow

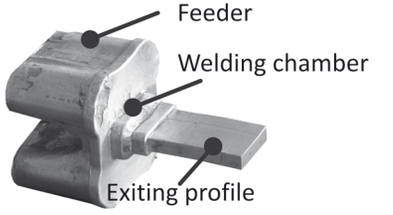
2.30 Recycling of Aluminum Chips by Metal Forming

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

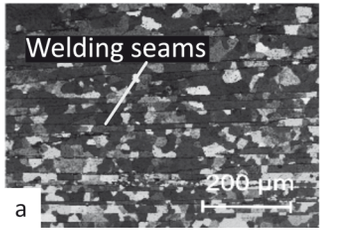
In this project, an alternative process for the recycling of aluminum chips is investigated. The aluminum chips can be directly extruded to produce aluminum profiles instead of recycling by re-melting, which has been common practice to the present.
Due to the good formability of aluminum as a material, chips can be chosen from different aluminum alloys and can also be mixed with other scrap material or ceramic materials to produce aluminum-based composite materials.
The material properties of the extruded profiles made of chips are investigated by various tests like tensile tests, creep tests, charpy tests, corrosion tests as well as microstructural investigations and are also compared to those of conventionally produced profiles.
The economical and ecological aspects of recycling of aluminum chips by direct extrusion are also discussed within scope of this project.

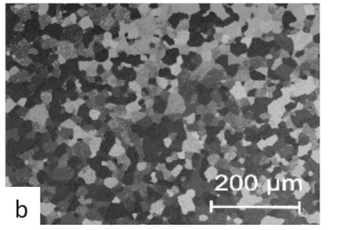


Loading of a chip billet



Material flow inside the die



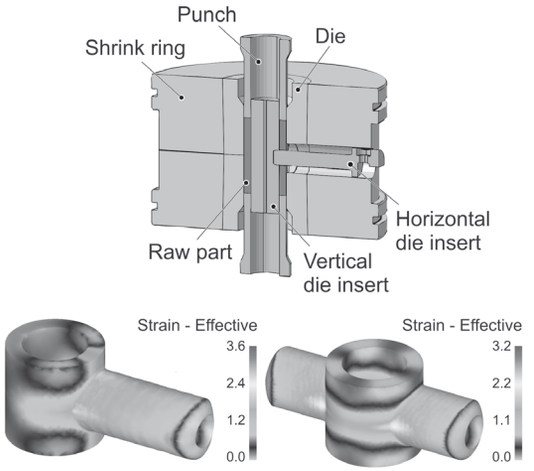


Microstructure of extruded profile from a) chips b) as-cast billet

2.31 Basic Investigations on Hollow Lateral Extrusion of Additional Shape Elements

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

Within the scope of this joint project between IUL and IFU (Institute for Metal Forming Technology of the University of Stuttgart), major focus is put on enhancing the basic knowledge on manufacturing of complex hollow shapes by a hollow lateral extrusion process.
The relation between geometry, process parameters as well as tribological aspects has to be analyzed by means of extensive experimental and numerical investigations.
Based on the gained results the parameters influencing material flow and tool wear have to be identified in order to optimize tool concepts. In addition, analytical models shall be derived to predict the manufacturability and feasibility of additional shape elements incorporated into hollow shaped products. Within the scope of lightweight design, this manufacturing method offers an innovative alternative for the production of structural- and weight-optimized components.

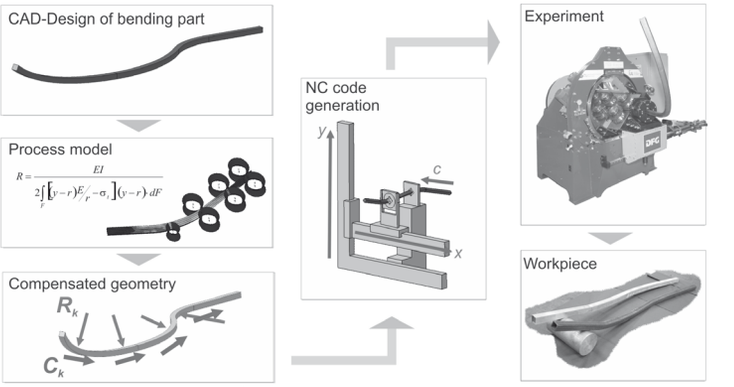


Experimental tool (IFU Stuttgart) and simulated components

2.32 3D Bending of Profiles Using Stress Superposition

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

The aim of the present research project is 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 bend-ing contour leading to more flexibility and cost efficiency, especially in small to medium batch production.
To define the spatial geometry of the workpiece a torque is superposed on the bending moment. In the first research period the focus was placed on the design of a special machine which was built and developed at the IUL. Current work includes experimental investigations of the process to verify the analytical model and a FEprocess simulation. At the same time these basic research results are used for the development of a process planning tool to calculate a NCcode for applied workpieces.
The process planning tool uses the semi-analytical calculation to design a springback-compensated bending part. This part represents the input data for a kinematic simulation to generate the NCcode. First bending results have shown a good accuracy.

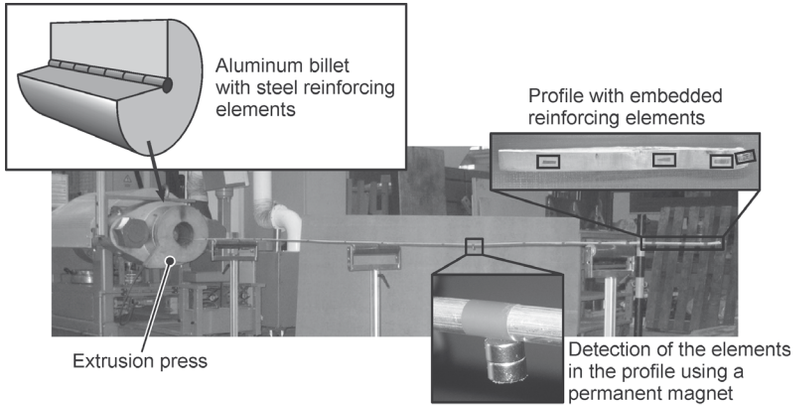


Principle of process planning for the TSS bending process

2.33 Component Optimization by Forging of Composite Aluminum Extrusions

Funding	German Research Foundation
Project	TE 508/17-1
Contact	Dipl.-Wirt.-Ing. D. Pietzka

Within the scope of this project the manufacture and further processing of selectively reinforced material compound components within the process chain extrusion and hot forging is analyzed. The reinforcement exists in non-stirred but discrete form.
Composite and co-extrusion processes are used to produce partially reinforced semi-finished compounds and in further processing steps the hot forging of the material compounds will be investigated. The light metal aluminum is used as matrix, in which a second high strength or high stiff component is embedded during co-extrusion.
The forging of the extrusions will be done by the Institute of Metal Forming and Metal Forming Machines of the University Hannover. The main focus of the research is on the arrangement of the material flow of the partially asymmetrical geometries, on optimized compound properties and on a high degree of lightweight design by high stiffness and strength at less density.

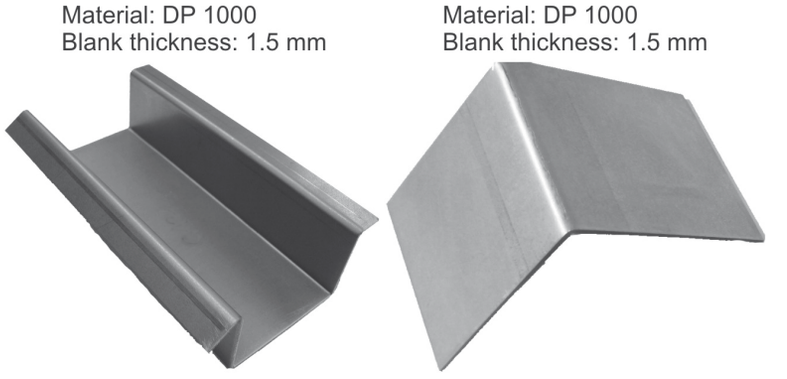


Manufacture of material compounds by extrusion

2.34 Development of Basics for the Selection and Process-reliable Design of Bending Procedures to Manufacture Profiles Made of Innovative Steel Materials

Funding	Forschungsvereinigung Stahlanwendung e.V.
Project	P 789
Contact	M. Sc. M. M. Gharbi • Dipl.-Ing. A. Weinrich

In the scope of this project, suitable forming procedures for the manufacturing of profiles made of high and ultra high-strength steels will be systematically analyzed, compared, and, if necessary, further developed.
The aim is to select the best manufacturing procedure and to determine the process parameters for a given profile geometry and the use of innovative steel materials in order to purposefully maximize the exploitation of the material and the procedure potential.
In this study, two different profile geometries (a V-profile and an asymmetric profile) will be produced with different proce-dures, bending and roll forming. Based on the V-profile, the basic investigation of both processes using experimental tests and FEsimulations will be performed and further developed.
Moreover, by the analysis of the asymmetric profile the applications of both procedures will be compared and the differences of both processes will be observed.

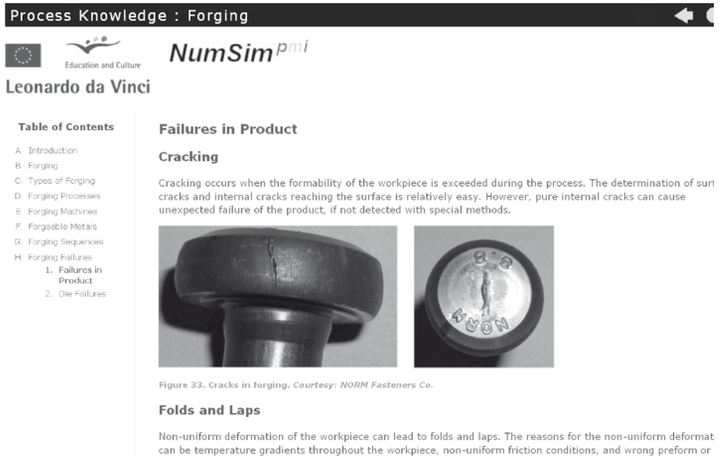


Left: asymmetric geometry (demonstrator); right: V-profile

2.35 Numerical Simulation in Process and Manufacturing Industries

Funding	EU-Project
Project	NUMSIM PMI
Contact	M.Sc. K. Demir

This project was completed in June 2009. Online training courses for the finite element simulation software users in the manufacturing industry were prepared. The purpose of the modules is to help simulation practitioners become simulation experts.
Universities collaborated with metal forming and simulation software development companies from several European countries: Swansea University, University of Milan Bicocca, Warsaw University of Technology, IMK Automotive GmbH (Germany), Physica Ltd. (UK), Norm Fasteners und ORS Bearings (Turkey). Training modules covered forging, extrusion, sheet forming and casting processes.
The topics to be handled for each process were determined by questionnaires and interviews with simulation experts from industry. In the course material, first, the physics of a process is explained. Then, detailed information about its simulation, case studies, and benchmark results are given. The courses are published on the World Wide Web (www.numsimpmi.eu).

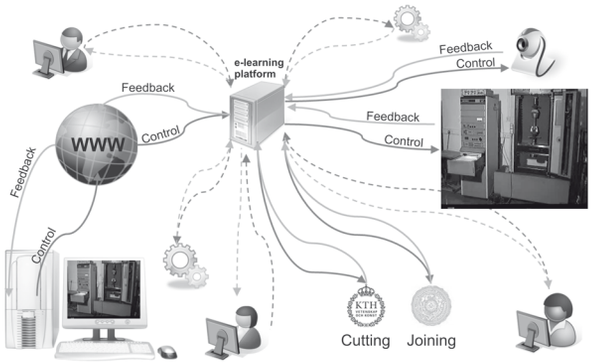


A snapshot from the training module on forging failures on the project website

2.36 PeTEX - Platform for E-Learning and Telemetric Experimentation

Funding	EU, Leonardo da Vinci
Project	142270-LLP-1-2008-1DE-LEONARDO-LMP
Contact	M.Sc. M.Eng. Ch. Pleul, né Burkhardt

The competitiveness of European enterprises depends on the presence of basic attributes as the capacity for innovation, flexibility, competence, and highly qualified employees. The “PeTEXproject - which is funded by the “Leonardo da Vinci” program as part of the “European education and training program” - intends to promote these attributes by an innovatively designed and integrated environment of telemetric experimental units.
The aim of this project is to develop a prototype for using several teleoperative experimental units in an e-learning environment in the context of further education and skill improvement in the field of manufacturing technology. Therefore, testing facilities for the uniaxial tensile test, milling, and friction stir welding are prepared at the locations involved (IUL, Germany; University of Palermo, Italy; Royal Institute of Technology Stockholm, Sweden). These facilities are connected by being telemetricly used by students and scientists in the interactive e-learning environment Moodle. In addition, the integration of specially designed contents of learning in an innovative e-learning scenario (developed by the Center for Research on Higher Education and Faculty Development (HDZ), TU Dortmund) supports the dissemination of specialized knowledge combined with cooperative learning and learning in communities.



The principle of teleoperated experiments included in a platform for e-learning

2.37 European Production Engineering Certification

Funding	EU, Leonardo da Vinci
Project	EPRODEC
Contact	Dr.-Ing. habil. S. Chatti

Modern production engineers must be able to perform a wide variety of tasks with steadily increasing complexity. In this context, it is especially important to provide production engineers with cross-disciplinary knowledge since this is vital to changing technology and international competition. Therefore, production engineering (PE) curricula must keep pace with the changes demanded by future trends in advanced manufacturing. For this reason, a homogenous PE curriculum that specifies the most important areas in this field and a European certification system that can measure the skills and the educational knowledge level are of great importance.
The goal of the Leonardo da Vinci project EPRODEC is to establish a unitary, transparent European training and certification system in Production Engineering based on EUR-ACE Framework Standards for the Accreditation of Engineering Programs.
The major elements in this system are

- a European organizational structure (EPRODEC Accreditation Body),
- procedures and practices for the assurance and maintenance of academic standards (the Quality Assurance Manual),
- an educational plan (EPRODEC Curriculum),
- an educational package (EPRODEC Educational Resources), and
- a validation instrument to attest acquired knowledge of both educators and trainees (the European Production Engineer Certificate).

The curriculum for a production engineering certification was developed in the previous Leonardo da Vinci project EPRODE. Partners of EPRODEC are institutes from universities in Sweden, Germany, England, and Italy along with industrial institutes and organizations in Denmark, Spain, and Sweden. Furthermore, representatives of both employees' and employers' organizations in Sweden as well as large European engineering organizations such as FEANI are EPRODEC partners.

2.38 A New Modular Educational Program in Production Engineering

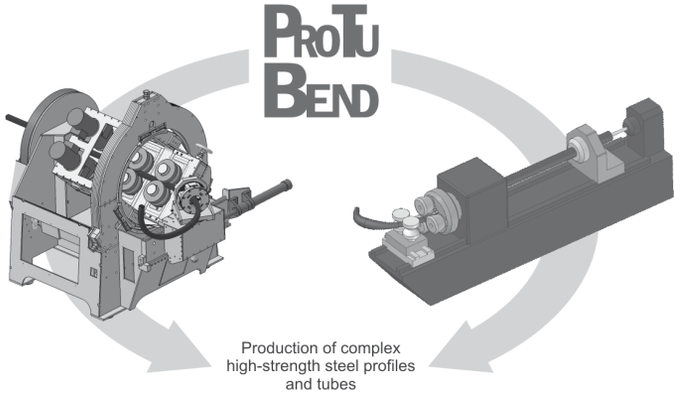
Funding	EU, TEMPUS
Project	MEDPRO (JEP_33157_2005)
Contact	Dr.-Ing. habil. S. Chatti

Today, Tunisia looks forward to an active technology transfer. One of the national projects that have a great effect on the Tunisian national economy is the "modernization of Tunisian industry". To achieve this program in a consistent way it is essential to prepare a new generation of engineers that can cope with the latest advances in technological aspects related to industry.
For the development of a new modular educational program in Production Engineering (PE) for the Tunisian bachelor and continuing education, which is based on the Bologna process, a new project has been initiated in 2007. It has been granted by the EU Program TEMPUS and is aimed at establishing and improving PE curricula for production engineers.
The aim of the MEDPRO project is to anticipate the needs for education of Tunisian manufacturing organizations and to provide a new generation of production engineers meeting these needs. The long term objective is to vitalize the Tunisian manufacturing industry and to strengthen its competitiveness on the global market.
Institutes from universities and the industry sector in Sweden, Germany, Poland, and Tunisia are partners of this project. The European dimension in the cooperation in PE education implies not only a guarantee for a common level of knowledge and skills for the graduates, but also assures a high quality level for teachers and the sustainability of the PE education.
The MEDPRO project focuses on the establishment of a new modular program in PE at the Ecole Supérieure de Sciences et Techniques de Tunis (ESSTT). Due to its modular structure the goal of the program is to establish the undergraduate education (BSc) and the training of production engineers in Tunisian companies for a long life learning activity.

2.39 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

The realization of ultra-light, economical, and ecologically oriented component structures with high contour complexity in the automotive industry necessitates the use of profiles and tubes made of innovative high-strength steel grades. An unsolved problem so far is the cost-effective and reliable manufacturing of these components in small or medium batch sizes.
The aim of the ProTuBend project is to advance the Tor-que Superposed Spatial (TSS) bending process and the Incremental Tube Forming (ITF) process for the industrial use capable of forming and bending load-optimized 3D tubes and profiles made of high and ultrahigh-strength steel. Both processes offer the advantage of a highly flexible kinematic definition and a reliable manufacturing of the bending contour. The superposition of stresses in the forming zone of both processes increases the process stability and predictability, by minimizing springback at the same time.
The project is done in cooperation with the European institutions TECOS, ASCAMM, ASERM, CRF, FOSTA, and FAURECIA.

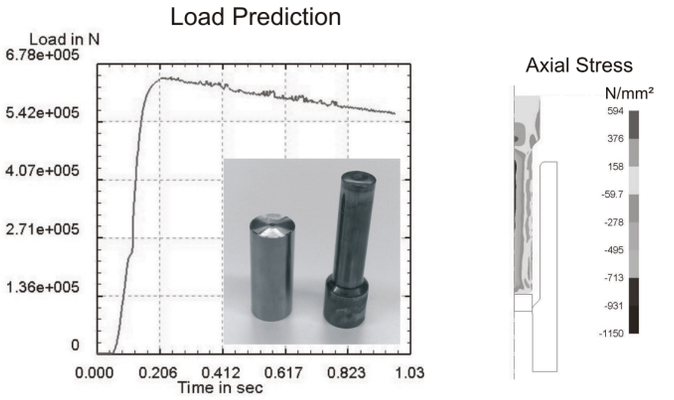


Goal of the ProTuBend project using the TSS bending process (left) and the ITF process (right)

2.40 Analysis of the Interactions Between Heat Treatment and Distortion of Cold Forging Workpieces

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

The procedure of cold forging allows an economic manufacturing of complicated and form-exact workpieces in large quantities. However, with the often following heat treatment it can come to a distortion of the component. Within the scope of this project, the interactions between heat treatment and distortion of accordingly formed workpieces are examined.
In extensive series of experiments with increasingly more complicated components different process parameters like material, degree of deformation, or lubricant are varied and the component qualities are analyzed. Besides experimental investigations, suitable FEM simulations with systematic variation of different process parameters also take place. In addition, components from the industrial manufacturing are examined in more detail.
Finally, recommendations and general optimization attempts will be derived from the results.

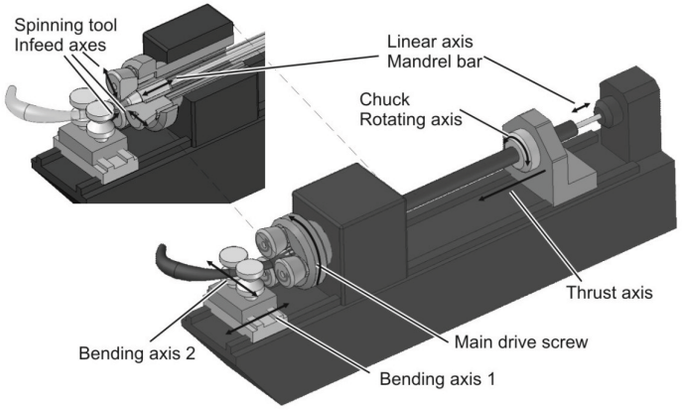


FEM simulation of the direct impact extrusion
(on the left: load prediction, on the right: residual stress)

2.41 Investigation and development of a process and a machine technology for Incremental Tube Forming

Funding	BMWi / ZIM-KF
Project	KF2198101LK9
Contact	Dipl.-Ing. Ch. Becker

The aim of this project, which is carried out in cooperation with transfluid®, Schmallenberg, is the investigation and development of a manufacturing process and a machine technology for Incremental Tube Forming (Inkrementelles Rohrumformen, IRU). The IUL submitted a patent application for Incremental Tube Forming. The process itself is a combination of the spinning process and a free-form bending process for tubes. It starts with a steady diameter reduction by a spinning tool which rolls the tube over the circumference. After this, a free-form bending process is superposed which causes a reduction of bending force and springback.
After pointing out the requirement specifications a prototype will be developed. The prototype will be used to identify the boundaries and dependencies of the new technology with regard to different tube materials. These results will serve as a basis to optimize and improve the prototype technology.

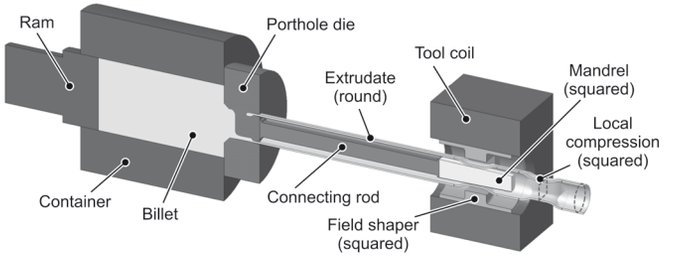


Incremental Tube Forming, machine setup

2.42 Patent Application Process and Device for Extrusion and Subsequent Electro-magnetic Forming

Patentnumber	DE 102009039759.0
Patentholder	Technische Universität Dortmund
Status	Filed
Inventors	Dipl.-Ing. A. Jäger • Dr.-Ing. D. Risch Prof. Dr.-Ing. A. E. Tekkaya

The invention concerns a process combination con-sisting of hot metal extrusion and subsequent applied electro-magnetic compression and quenching. A profile, manufactured by hot extrusion, is pressed through a tool coil for electromagnetic compression. Here, the workpiece is compressed locally in a contactless forming operation and subsequently quenched.
By integrating the electromagnetic forming operation into the process chain of extrusion the process heat remaining in the workpiece after extrusion can be used for the following forming and heat treatment operation.
The integrated processing strategy is applicable for manufacturing straight tubular products with locally geometrically modified cross sections in a quasi continuous process. In comparison to conventional processing strategies, benefits in productivity and energy efficiency are noticeable.
By using a counter die in the shape of a mandrel, which is mounted to the mandrel of a porthole extrusion die and protrudes into the tool coil, more defined and manifold geometries can be manufactured.

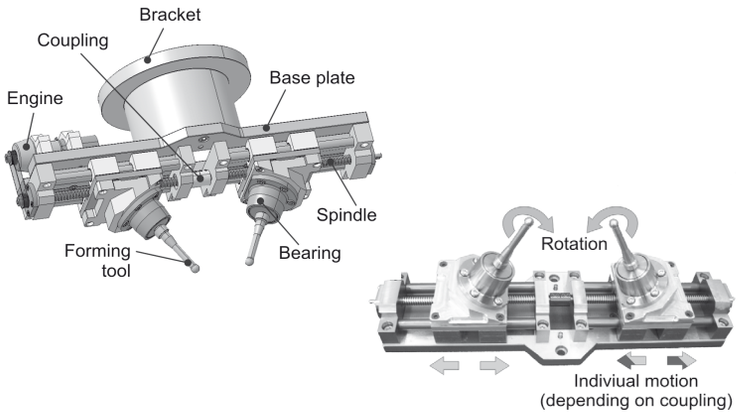


Process combination of hot metal extrusion and electromagnetic compression

2.43 Patent Application
Multizone-tool for Incremental Sheet Metal Forming

Patentnumber	10 2009 025 726.8
Patentholder	Technische Universität Dortmund
Status	Filed
Inventors	Dipl.-Ing. L. Kwiatkowski
	Prof. Dr.-Ing. A. E. Tekkaya

Incremental sheet metal forming is a very flexible but slow forming process. Introducing a new tooling concept, several zones of the workpiece can be formed simultaneously. This procedure allows reducing the process time significantly.
The new tooling concept can be used to manufacture hollow bodies with nearly any desired contour. Flat or preformed sheets can be used as semi-finished parts. Principally the same forming tools can be used to work on different production tasks. In general the technique of incremental sheet metal forming can be utilized for the manufacturing of parts with low batch size or for prototyping. The new developed tool extends the range of application towards larger batch sizes.
An application for a patent was submitted to the German Patent and Trademark Office in June 2009. A first prototype, called “TwinTool”, is currently in the state of development at the Institute of Forming Technology and Lightweight Construction



Prototype “TwinTool” for the reduction of process time

2.44 Cooperations

At this point we would like to express our gratitude to the large number of various cooperation partners in 2009 which have added to our joint success.

University cooperations

University cooperations at national level

- Fachgebiet Fluidtechnik, Technische Universität Dortmund
- Fraunhofer-Institut für Werkzeugmaschinen und Umformtechnik, Technische Universität Chemnitz
- Lehrstuhl für Wissenschaftliches Rechnen, Technische Universität Dortmund
- Lehrstuhl für Werkstoffkunde, Universität Paderborn
- Lehrstuhl für Werkstofftechnik, Universität Rostock
- Lehrstuhl für Werkstofftechnologie, Technische Universität Dortmund
- Materialprüfungsanstalt, Universität Stuttgart
- Professur Werkstoffe des Maschinenbaus, Technische Universität Chemnitz
- Hochschuldidaktisches Zentrum, Technische Universität Dortmund
- Institut für Bildsame Formgebung, Rheinisch-Westfälische Technische Hochschule Aachen
- Institut für Fertigungstechnik und Werkzeugmaschinen, Leibniz Universität Hannover
- Institut für Festkörpermechanik, TU Braunschweig
- Institut für Massivbau, Technische Universität Dresden
- Institut für Metallurgie, Technische Universität Clausthal
- Institut für Produktionstechnik und Umformmaschinen, Technische Universität Darmstadt
- Institut für Spanende Fertigung, Technische Universität Dortmund
- Institut für Umformtechnik, Universität Stuttgart

- Institut für Umformtechnik und Umformmaschinen, Leibniz Universität Hannover
- Institut für Werkstoffkunde, Leibniz Universität Hannover
- Institute für Mechanik, Technische Universität Dortmund
- Laboratory for Chassis Suspension Technology, FH Osnabrück
- Lehrstuhl für Fertigungstechnik und Werkzeugmaschinen, Universität Siegen
- Lehrstuhl für Fertigungstechnologie, Friedrich-Alexander-Universität Erlangen-Nürnberg
- Lehrstuhl für Leichtbau, Technische Universität München
- Lehrstuhl für Umformende und Spanende Fertigungstechnik, Universität Paderborn
- Institut für Werkzeugmaschinen und Betriebswissenschaften, Technische Universität München
- Lehrstuhl für Umformtechnik und Gießereiwesen, Technische Universität München
- Institut für Werkstoffkunde I, Karlsruher Institut für Technologie (KIT)
- wbk Institut für Produktionstechnik, Karlsruher Institut für Technologie (KIT)

University cooperations at international level

- Center of Manufacturing and Industrial Management (CMIM), Universidade Técnica de Lisboa, Portugal
- Construerende Technische Wetenschappen, Technische Mechanica, Universiteit Twente, Niederlande
- Department of Mechanical Technology, Production and Management Engineering, University of Palermo, Italy
- Department of Materials Science and Engineering, The Ohio State University, Ohio, USA
- DIEM-Tech Manufacturing Technology Group of the University of Bologna, Italien
- Institut Charles Delaunay, Labarotoire des Systèmes Mécaniques et d'ingénierie Simultanée (LASMIS), Université de Technologie de Troyes, Frankreich

- Institute for Manufacturing, Department of Engineering, University of Cambridge, Großbritannien
- Loewy Chair in Materials Forming and Processing, Institute for Metal Forming, Lehigh University, Bethlehem, Pennsylvania, USA
- Metal Forming Center of Excellence Capabilities, Atilim Universität, Ankara, Türkei
- Royal Institute of Technology KTH, Department of Production Engineering, Stockholm, Schweden
- School of Materials Science & Engineering and the Department of Plasticity Forming Engineering at Shanghai Jiao Tong University, China
- School of Engineering, Swansea University , Wales, Großbritannien
- Technische Universität Cluj-Napoca, Klausenburg, Rumänien
- University of Milano Bicocca, Mailand, Italien
- Warsaw University of Technology, Warschau, Polen

Industrial cooperations at national and international level

- Airbus S. A. S.
- Alu Menziken AG, Schweiz
- ALUTEC Leichtmetallfelgen GmbH
- ARBURG GmbH + Co KG
- AUDI AG
- Benteler AG
- BMW AG
- borit Leichtbau - Technik GmbH
- BRUDERER AG
- Corus Strip Products, England
- Daimler AG
- Data M Sheet Metal Solutions GmbH
- Erbslöh Aktiengesellschaft
- EvoBus GmbH
- Faurecia Autositze GmbH
- Forschungsvereinigung Stahlanwendung e. V.
- Hirschvogel Umformtechnik GmbH

- Hydro Aluminium Deutschland GmbH
- imk automotive GmbH
- JFE Steel Corporation, Japan
- Johnson Controls Hilchenbach GmbH
- Koda Stanz- und Biegetechnik GmbH
- LEIBER Group GmbH & Co. KG
- NORM Civata Sanayii ve Ticaret A.S., Türkei
- Novelis Technology AG
- ORS Bearings / Ortadogu Rulman Sanayi A.S., Türkei
- Otto Fuchs KG
- Poynting GmbH
- Physica Ltd.
- Rehau AG + Co
- Repkon, Istanbul, Türkei
- Robert Bosch GmbH
- Salzgitter Mannesmann Forschung GmbH
- Salzgitter Mannesmann Präzisrohr GmbH
- Schuler AG
- Schwarze-Robitec GmbH
- Siemens Aktiengesellschaft
- SMS Meer GmbH
- SSAB Swedish Steel GmbH
- SSAB Tunnplåt AB, Schweden
- ThyssenKrupp Steel AG
- TRACTO-TECHNIK GmbH & Co. KG Spezialmaschinen
- Transfluid Maschinenbau GmbH
- TRUMPF Werkzeugmaschinen GmbH + Co. KG
- Viessmann Werke GmbH & Co KG
- Voestalpine AG
- VOLKSWAGEN AG
- Welser Profile GmbH
- WF Maschinenbau und Blechformtechnik GmbH & Co. KG
- Wickeder Westfalenstahl GmbH

- 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.
- CIRP - The International Academy for Production Engineering
- Deutsche Gesellschaft für Materialkunde e.V.
- Esaform European Scientific Association For Material Forming
- Europäische Forschungsgesellschaft für Blechverarbeitung e.V.
- FOSTA - Forschungsvereinigung Stahlanwendung e.V.
- GCFG - German Cold Forging Group
- ICFG - International Cold Forging Group
- IDDRG - International Deep Drawing Research Group
- I^2FG - International Impulse Forming Group
- Industrieverband Blechumformung
- Industrieverband Massivumformung
- Gesamtverband der Aluminiumindustrie e.V.
- Leichtbaucluster
- TMS The Minerals, Metals & Materials Society Inc.
- VDI - Verein Deutscher Ingenieure e.V.
- VDW Verein Deutscher Werkzeugmaschinenfabriken e.V.
- Wirtschaftsverband Stahl- und Metallverarbeitung e.V.
- WGP - Wissenschaftliche Gesellschaft für Produktionstechnik

Foundations

- Karl-Kolle-Stiftung
- VolkswagenStiftung

3 Further Activities

3.1 Conferences and Meetings

The following conferences and workshops were hosted by the Institute of Forming Technology and Lightweight Construction to present research results and to meet researchers from industry and universities.

- Lightweight symposium and colloquium of the Transregional Collaborative Research Center SFB/TR10, February 5
- Workshop on „Impulse Forming“, March 12
- Workshop on „Simulation in Forming Technology“ , main topic: validation of process simulation in sheet metal and massive forming; in cooperation with the Institute for Metal Forming Technology and the Institute of Statics and Dynamics of Aerospace, Universität Stuttgart,
  location: IUL, TU Dortmund, March 26 - 27
- MFPT 2009 (Department of Materials Forming and Control Engineering, Northwestern Polytechnical University, China), SINO-German Workshop, April 5 - 9
- 2nd Workshop on „Optimization in Production Technology“, June 16 - 17
- ICEB - International Conference on Extrusion and Benchmark, September 15 - 17
- DGM- Further training seminar on deep drawing, November 5 - 6
- DORP09 – „3rd Conference on Tube and Profile Bending in Dortmund”, October 8
- Workshop on bending („Biegen in Siegen“), October 7
- Seminar on press hardening, December 14 - 15

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

- Host of this year’s graduate ceremony of the Faculty of Mechanical Engineering, January 23 at the IUL experimental hall
- Girls‘ Day, April 23
- Student exchange within the scope of the International Summer Program (ISP) at TU Dortmund, Mai 23 - August 10
- Campus Open Day, June 20
- do-camp-ing, July 7 - 8
- Stahl fliegt (Flying steel), July 24
- SENAI St. Catarina delegation from Brazil visits the IUL within the scope of a one-week tour of Germany, August 28
- „To Kyoto for one hour“, October 14
- SchnupperUni, October 12 - 15

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

Lightweight Symposium and Colloquium of the Collaborative Research Center SFB/Transregio 10

The common research objective of the six institutes and chairs being part of the Collaborative Research Center SFB/Transregio 10 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 space frame structures. 72 participants from 15 industrial firms and 10 research institutions joined in the discussion on this topic during this one-day SFB/Transregio 10 event. Lectures concerning industrial research and fundamental research of the SFB/Transregio 10, the Institut für Leichtbau und Kunststofftechnik of the TU Dresden, and the Collaborative Research Center 396 offered the opportunity for interdisciplinary exchange. Research work and results of the Collaborative Research Center SFB/Transregio 10 were presented as well as ways to integrate them into a flexible, modern industrial production. These research results were obtained during the second funding period of the SFB/Transregio 10, which is funded by the German Research Foundation since 2007.

Participants of the Lightweight Symposium

Workshop – Impulse Forming

A workshop on the topic “Impulse Forming” was held on March 12, 2009, following four successful national workshops within the scope of „Electromagnetic Forming”. First results of the research project “Development of a Methodology Regarding Combined Quasi-static and Dynamic Forming Processes“, which is financially supported by the German Research Foundation, were presented.

Furthermore, contributions from other universities and industry respectively completed the workshop’s program in order to enhance the scientific spectrum. The purpose of this conference was to bring together technical and scientific experts to encourage the exchange of knowledge and to establish a forum for the discussion of state-of-the-art as well as future aims in the field of impulse forming.

12th Workshop on „Simulation in Metal Forming“

The twelfth workshop on „Simulation in Metal Forming” was held on March 26 and 27, 2009, at Technische Universität Dortmund. The organization was a collaboration between the IFU and ISD, two institutes at Universität Stuttgart, and the IUL. The main topic of this year’s workshop was the validation of process simulations in sheet and bulk metal forming. Here, questions of validation were analyzed and discussed taking different aspects by means of the transferable validation data and analytical, numerical, and experimental results into account. The large variety of workshoppresentations helped launching a dialog between more than 100 participants from universities and industry by an active exchange of experience.

Impression of the workshop „Simulation in der Umformtechnik“

Conference: „Second Sino-German Workshop on Metal Forming Processes and Technology“

The second „Sino-German Workshop on Metal Forming Processes and Technology“ was held at the Institute of Forming Technology and Lightweight Construction (IUL) at Technische Universität Dortmund from April 5 till April 10, 2009. This workshop, sponsored by the Sino-German Center for Research Promotion, was organized by Technische Universität Dortmund (Germany) and Northwestern Polytechnical University (China) and was hosted by the IUL.
Thirteen Chinese professors and twelve German professors were invited to attend the conference. They exchanged their experiences and ideasand discussed recent advances in all branches of forming technology. The conference provided a platform for academic discussion and the chance to initiate further cooperation on some potential topics.
In a first step, a student exchange between universities from both countries was planned in order to broaden the research cooperation between the universities of Germany and China. Ideas and plans concerning bilateral scientific cooperation have been put forward. Research purposes regarding fundamental issues were decided as a precondition for future cooperation projects.

Group photo of the workshop participants at the IUL, TU Dortmund

2nd Workshop on „Optimization in Production Technology“

This workshop was the second in a series of events aiming at a systematic transfer of methods from mathematics and informatics in the field of optimization to solve current production-related problems. From a production engineer’s point of view, finite element analyses are a well-established tool. They can be used for the identification of process-relevant parameters and, in combination with unspecific and, therefore, in most cases inefficient optimization strategies, for the identification of suitable product and production parameter sets. In many cases, this inefficiency contradicts a successful optimization since a large number of design parameters is given and the analysis of the quality function requires long computation times. However, optimization strategies are essential for an economic process design of complex manufacturing processes.
By defining benchmarks the workshop laid the foundation for an evaluation and further development of optimization processes adapted to production technology. For this purpose, two to three benchmarks from the field of production technology were presented and put up for discussion in order to be further developed. Furthermore, key activities were discussed and specified which, owing to their potential, shall be specifically advanced in the future.

International Conference on Extrusion and Benchmark ICEB 2009

Under the patronage of the IUL and the Department of Mechanical Construction Engineering (D.I.E.M.), Uni-versity of Bologna, the International Extrusion Confe-rend and Benchmark ICEB 2009 was held in Dortmund on September, 16th and 17th.
The conference was aimed at presenting the last adavances in extrusion technology and its simulation and focused on current research topics such as material flow, dies, tools and microstructure. The conference was attended by more than 152 participants from 27 countries.

Audience at the International Extrusion Conference and Benchmark ICEB 2009

3rd Conference on Tube and Profile Bending in Dortmund - DORP 2009

After two successful conferences held in 2005 and 2007, the 3rd Conference on Tube and Profile Bending in Dortmund (DORP) welcomed its participants on October 8, 2009. The event once again offered professionals from universities and the industry a platform for an intensive exchange of knowledge and experience. Despite the economic crisis, there was large attendance and much interest on the part of the industry.
The main aspects of the conference were tube bending, profile bending, forming technologies, and process chains. Particulary the topics ofcurrent process limits, economic production, and the use of new types of forming tools were subject of a lively discussion.
In addition to the lectures a small exhibition was organized which served as an incentive for further discussions. Furthermore, the possibility of a visit to the extensive experimental area of the IUL was offered

Impressions of the DORP 2009

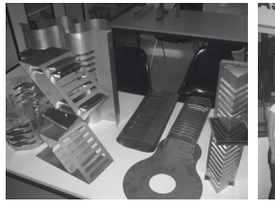
Summer Holiday Program for Children

This summer, the IUL initiated a summer holiday program for children of employees. The program took place within the scope of the Collaborative Research Center Transregio 73.
Members of the IUL set the framework providing an adequate room (including a kitchen), a transporter, which was used for trips, and organized the funding.
Two aspirants of a teaching degree were responsible for the preparation, realization and the wrap-up of the program.
Following the motto "We are an Indian tribe", the children were entertained with a number of trips (museum "Mondo Mio", Westfalenpark, Fredenbaumpark, and zoo), indoor and outdoor games, creative activities, cooking, and a guided tour through the cafeteria of TU Dortmund University.

do-camp-ing 2009

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 2009, 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 were awarded this year's first prize among eight projects.

First draft ...



... finished product ...

... satisfied participants

SchnupperUni

SchnupperUni ("Get to know your university!") is an event organized by TU Dortmund for secondary school senior class students. For a week, they have the opportunity to look around the university to get to know scientific and technical curricula, current research projects, professors and lecturers, future fellow students, the life of students in general, and professionals from scientific-technical departments.183 senior class students took part in SchnupperUni 2009. All in all, participants were offered about 67 lectures and workshops, one of them took place at the IUL.
The IUL seminar dealt with the topic: "How to form cars/airplanes made of metal". The following questions could be resolved:
1) Where is forming technology implemented?
2) What is forming technology?
3) What fields of activity are covered by forming engineers?

Girls' Day

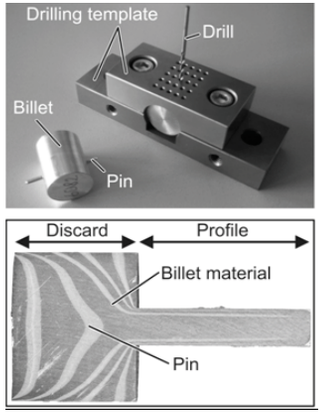
This year's Girl's Day motto was „Forming technology – live!". Six girls aged 12 to 14 took part in the project and were mentored by IUL staff members. They had the chance to experience both "live", informative presentations on forming technology as well as performances of manufacturing processes based on forming technology concepts in the IUL experimental area. In addition to a general tour around the hall special focus was put on the method of deep drawing. A theoretical explanation was followed by a deep drawing experiment which also demonstrated the event of a failure in the form of wrinkling. By operating the machine themselves the girls were directly involved in the experiment. A sheet metal bearing the Girl's Day logo was formed into a tea light candle holder, serving as a souvenir to take home for the participants. This year's Girl's Day was supervised by Qing Yin and Annika Foydl.

Participants of Girls' Day

Student Exchange within the International Summer Program at Technische Universität Dortmund

TU Dortmund invites students from abroad to an annual International Summer Program in Dortmund. The courses focus on applied mathematics, engineering, and economics and are complemented by German classes.
Within the scope of this program Tiffany Chen and Carolyn Ferreira, two students from Lehigh University, Bethlehem, PA, USA, had the opportunity to work on a research project at the IUL, supervised by Andreas Jäger, dealing with the visioplastic analysis of the material flow in extrusion processes with AW-6060 and AW-6082 aluminum alloys.

Guest students C. Ferreira, T. Chen



Visioplatic analysis of hot extrusion

Stahl fliegt - Flying Steel

„Stahl fliegt“ (Flying steel) is an interdisciplinary ideas competition 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 and built an aircraft consisting completely of steel or other metals having an iron percentage of at least 70%. Students from RWTH Aachen University, Technische Universität Darmstadt, the University of Kassel, Technische Universität Dortmund, Saarland University, and the University of Bremen have been taking part in the competition.

Kinder –TU (Children’s University): “Churning out” automobiles: How a car bodies are made!

A car body is made of more than 300 sheet metal parts – some car models even require several thousand parts in one day. How does that work? How is a thin sheet metal made of steel or aluminum turned into a car door without wrinkles, bumps, or cracks? Is a car really “baked” in an oven to become solid? What kinds of machines are used to produce cars? Professor Kleiner answered all these questions relevant for those small sportsters. The visit of the IUL experimental area following the lecture in the university’s main auditorium was well-attended. On that day, the participating children experienced “hands-on” science.

Children visiting thel UL research area

Awards

Nooman Ben Khalifa was granted the “2009 ISPF Award for the Most Outstanding Presentation” for his work “Basic Investigations of Twisted and Helical Profile Extrusion of Aluminum Alloys” at the “5th JSTP International Seminar on Precision Forging” in Kyoto, Japan, hosted by the Japan Society for Technology of Plasticity.
Michael Trompeter received the „SheMet`09 Award for the Best Conference Paper“ for his paper “Hydroforming of Large-area Multi-cell Sheet Metal Structures” at the “13th International Conference on Sheet Metal” in Birmingham, England.
The invitations to present two keynote papers entitled „Influence of Cooling Rate on Distortion and Microstructure in Extrusion of Al-Mg-Si Alloys“ by Andreas Jäger and „Manufacturing of Lightweight Frame Structures by Innovative Joining by Forming Processes“ by Dr. Michael Marré as well as the plenary keynote lecture at ESAFORM 2009 in Enschede, The Netherlands, with the title „Innovation by Forming Technology: Motivation for Research“ by Professor Tekkaya, Head of the Institute, are a further proof of the internationally leading position of the Institute of Forming Technology and Lightweight Construction in the field of manufacturing technology. The results were achieved in the framework of basic research projects funded by the Deutsche Forschungsgemeinschaft (German Research Association).

The prize winners (from left to right):
Michael Trompeter, Nooman Ben Khalifa, Matthias Hermes

Plastics Bends Metal - Golden Manus® 2009

The golden manus® 2009, a prize awarded by the igus® GmbH for the innovative use of plain plastic bearings in tech-nological applications, was presented to the Institute of Form-ing Technology and Lightweight Construction. The awarded application is a system for the three-dimensional bending of profiles. The application uses a new production process which offers advantages especially for the bending of asymmetrical profiles. By superposing a torsional moment with the bending process the typical twisting of asymmetrical profiles which occurs in two-dimensional bending can be prevented. Fur-thermore, the bending accuracy of the application is very high.
The problem of high loads occurring in forming machines and the resulting high stresses on the machine was solved by the use of plain polymer bearings. As opposed to bearings made of bronze, the high strength and low-wear polymer bearings also withstand high edge pressures. With bearing diameters of up to 850 mm there is also a cost advantage compared to roller bearings.

The golden manus® 2009 of Matthias Hermes

Network of Automotive Excellence

On July 8 and 9, 2009, the process principle of Incremental Tube Forming (IRU), which has been developed by Matthias Hermes, scientific assistant at the Institute of Forming Technology and Lightweight Construction, by young scientist Bastian Kurze as well as by the institute's head, Prof. Dr.-Ing. A. Erman Tekkaya and which has already been filed as a patent, was chosen by the jury of the NoAE Innovation Contest (Network of Automotive Excellence) among the 30 most innovative ideas presented by 380 institutions. NoAE is a cross-company expert network for the automobile and supplying industry aiming at continuously strengthening the competitiveness of European automobile and supplier industries.
The award ceremony took place under the patronage of the German Federal Minister of Economics and Technology, Dr. Karl-Theodor Freiherr zu Guttenberg, within the scope of the "Würzburger Automobil Gipfel".
The Institute of Forming Technology and Lightweight Construction is currently working on the construction of a special purpose machine in cooperation with the machine manufacturer Transfluid Maschinenbau GmbH. Based on a resolution adopted by the German Bundestag, the project is funded by the Ministry of Economics and Technology.

The inventors Matthias Hermes and Bastian Kurze,
and the young scientist Daniel Staupendahl

„Patente Erfinder 2009“ - The Inventors Award Granted by the Ministry of Innovation and PROvendis Was Awarded to Matthias Hermes for a 3D Profile Bending Machine

Matthias Hermes, winner of the third prize, was awarded a prize money of 8.000 Euros for his method specializing in forming tubes and asymmetrical profiles for lightweight applications in the automobile and aviation sector.
As the method is very flexible with regard to design aspects it is more cost-efficient than conventional methods, particularly for small and medium quantities. Conventional methods are often more expensive at a limited design flexibility.
A prototype of the bending machine consisting of a roller-based principle has already been developed. Computer-operated axes move roller systems, thus defining the bending contour. In order to form contours more flexibly the profile, including the roller system unit, can additionally be twisted around its longitudinal axis. Thus, space curves of almost any desired type can be produced.

From left: Staatssekretär Dr. Michael Stückradt, Matthias Hermes

3.2 Further Education

Further education is a matter of course for IUL staff members. In the following, a choice of the major professional training measures is listed, including courses to enhance technical, educational, and soft skills of the staff members.

Further Education Science and Theory

- WGP Summer School 2009 on „Intelligent Production Systems“, July 21 - 28, 2009, organized by the Institute of Industrial Manufacturing and Management (IFF) and the Institute for Control Engineering of Machine Tools and Manufacturing Units (ISW) in cooperation with the Fraunhofer Institute for Manufacturing Engineering and Automation (IPA), Stuttgart
- Further training of the working group „Component Properties and Functions“ within the scope of SFB TR 73, subject: materials (fundamentals, adjustment of material properties), November 25 - 26, 2009, Institute of Materials Science (IW), Hanover
- Friction in massive forming processes, December 2, 2009, organized by Industrieverband Massivumformung e.V., Hagen
- Lecture series „Introduction to tensor calculus” held by Professor Haupt as guest lecturer at IUL, October - December 2009, TU Dortmund

Further Education Software

- ABAQUS training, April 6, 2009, Institute of Mechanics, TU Dortmund
- Software training „Springback Compensation I“ for „Autoform“ software, May 5 - 6, 2009, Autoform Engineering Deutschland GmbH, Dortmund
- Adobe Photoshop CS3, September 21 - 22, 2009, IT and Media Center (ITMC), TU Dortmund

Further Education Hardware

- „Inspection of portable electrical equipment, part 1“, May 12 - 14, 2009, organized by Unfallkasse NRW, Duisburg
- Press setter seminar for specially trained press setters according to BGR 500 chapter 2.3, November 16 - 20, 2009, organized by Berufsgenossenschaft Maschinenbau und Metall, Schierke

Further Education Didactics

- Professional teaching competence for universities, „Examining by the terms of Bologna“, June 5 - 6, 2009, University of Paderborn
- Workshop „Start in teaching“ – a didactic introduction to teaching and learning, September 22 - 24, 2009, HDZ, TU Dortmund

Soft Skills and Social Competences

- „Finding one's own way - being one's own boss", May 4 - 5, 2009, PZH Hanover, Graduate College GRK 1378
- „Management, motivation, communication, and team work", further education program of the German Research Foundation, May 5 - 6, 2009, Munich
- „Preparing and attending evaluations“, further education program of the German Research Foundation, June 21 - 23, 2009, Günzburg
- „Career Day", organized by the German Research Foundation, October 1, 2009, Bielefeld
- CoachingPLUS „Leadership Skills“, ScienceCareerNet Ruhr, September 2 - 3, 2009, Dortmund
- Principles of internal communication, October 7 - 8, 2009, PZH Hanover, Graduate College GRK 1378
- Professionally giving lectures and presenting, November 19 - 20, 2009, FBZHL Erlangen, further training within the scope of SFB TR 73, Erlangen
- Health and safety at work – a task for workshop managers, December 7 - 8, 2009, organized by Unfallkasse NRW, Hagen

Administration and TU Management

- Using the digital filing plan, seminar for TU Dortmund employees, organized by the Center for Further Education, August 8, 2009
- Update on travel expenses law of the Federal State of North Rhine-Westphalia, organized by Technische Akademie Wuppertal, December 2, 2009

Operational and Occupational Safety

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

3.3 IUL Excursion

A close contact to partner institutes and industry is the basis for innovations made at IUL. Only in this way e.g. integrative lightweight concepts can be fully conceived and implemented. With this in mind, 40 IUL staff members set out on an excursion to Stuttgart from March 30 to April 3, 2009.

March 30, 2009

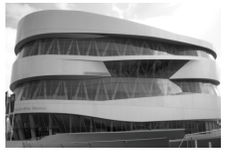
After an exhausting journey by bus the participants' initial curiosity was satisfied at the Institute for Materials Testing, Materials Science and Strength of Materials (IMWF) of the Universität Stuttgart. Especially the dimensions of some machines were impressive, e.g. the 100 MN tensile testing machine.

Dinner at the „Amadeus“ restaurant, Stuttgart

Prof. Tekkaya visiting the IMWF experimental area

March 31, 2009

Visiting the Mercedes-Benz Sindelfingen plant clearly showed the enormous complexity of today's car production. Subsequent to this state-of-the-art highlight the IUL excursionists visited the Mercedes-Benz Museum, accommodating a vast number of historic automobile beauties.



Mercedes-Benz Museum

Exhibit

April 1, 2009

This excursion day comprised visits to two local companies, Trumpf GmbH & Co. KG in Ditzingen and Schuler Pressen GmbH & Co. KG in Göppingen. At Trumpf, the innovative sheet metal processing machines and especially the assembly of complex laser units for laser cutting facilities was of particular interest. At Schuler Pressen, the focus was on the production of special purpose machines, giving an excellent general view of the range of products and particularly of the dimensions of the presses.

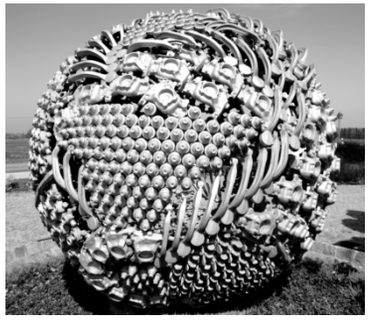
Necessary safety precautions at Schuler Pressen, Göppingen

April 2, 2009

A visit to Hirschvogel Umformtechnik GmbH in Denklingen was part of today's schedule, presenting the company's production area in the field of massive forming. Back in Stuttgart, the IUL staff members visited the Institute for Metal Forming Technology (IFU) of the Universität Stuttgart in order to swap ideas on current research topics, to exchange views on possible future collaborative projects, and to finish the day with a relaxed barbecue.

Group photo at Hirschvogel Umformtechnik GmbH, Denklingen

Barbecue at IFU, Stuttgart



Artwork at Hirschvogel Umformtechnik GmbH, Denklingen

April 3, 2009

The last excursion day led the IUL staff members to Alutec Metallwaren GmbH & Co. KG in Sternenfels, a company specialized on the production of extrusion parts. Driving back to Dortmund, the journey was interrupted for a last stop in Heidelberg where the participants enjoyed a guided tour around the city's historic center.

University library, Heidelberg

WGP Summer School 2009 – Intelligent Production Systems

This year's WGP Summer School was organized by the Institute of Industrial Manufacturing and Management, the Institute for Control Engineering of Machine Tools and Manufacturing Units, and the Fraunhofer IPA. Mr. Qing Yin participated on the part of the Institute of Forming Technology and Lightweight Construction . From July 21 until July 28, altogether 32 postgraduates from WGP institutes listened to lectures, participated in seminars and discussions, and delved into the topic "Intelligent Production Systems".

Working in groups, the participants generated new ideas on different topics:

- limits of modular production systems
- reduction of setting-up times for a whole plant
- cost efficiency analysis of versatile production systems
- simulation of machines and processes

Together, the young researches developed visions and strategies for future research projects and eventually discussed the results with their colleagues. Professor Engelbert Westkämper (IFF, IPA) was impressed by the final presentation: "This is certainly something the WGP can be proud of when presenting it to the DFG, which has supported the Summer School financially."
In addition to lectures and teamwork, an interesting variety of activities within the scope of the social program added to the Summer School's attractiveness, comprising guided tours through the Mecedes-Benz plant in Stuttgart-Untertürkheim and the FESTO AG in Denkendorf as well as a visit to the theatre "Depot" in Stuttgart for the play "The Glass Menagerie" by Tennessee Williams and an exciting go-cart race combined with a visit to the city of Tübingen. Thus, team spirit was developed by the participants which provides a soundbasis for cooperation of the WGP institutes in the future.

Participants of WGP Summer School 2009

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

Memberships of Research Boards

- CIRP - Fellow of the International Academy for Production Engineering
- acatech – Member of the German Academy of Science and Engineering (Deutsche Akademie der Technikwissenschaften)
- AGU – Member of „Wissenschaftlichen Arbeitsgemeinschaft Umformtechnik"
- GCFG – Member of the German Cold Forging Group
- ICFG – Chairman of the International Cold Forging Group
- ICTP – Member of the Standing Advisory Board of the International Conference on Technology of Plasticity
- I^2FG – 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 Jioa Tong University, Shanghai, China
- Overseas professorship at Anna University, Chennai, India
- Curatorship member of „Karl-Kolle Stiftung", Dortmund, Germany
- Full professor at the Department of Mechanical Engineering, Atilim University, Ankara, Turkey
- Founding director of the Center of Excellence for Metal Forming, Atilim University, Ankara, Turkey

- Co-organizer of ICTP 2011, Aachen, Germany (together with Prof. G. Hirt, RWTH Aachen)
- Member of the Scientific Advisory Board of „Exzellenzcluster Integrative Produktionstechnik für Hochlohnländer" of RWTH Aachen University

Journals Editorship

- Editor-in-Chief of the „Journal of Materials Processing Technology" (Elsevier)
- Member of the Editorial Board of the „Journal of Manufacturing Science and Technology" (Elsevier)
- Member of the International Editorial Board of the „Journal of Computer Methods in Materials Science"
- Member of the Scientific Circle of the Journal "Steel Grips" - Journal of Steel and Related Materials
- Member of the International Advisory Committee of the "International Journal of Material Forming" (Springer)
- Member of the Scientific Editorial Board of the "International Journal of Precision Engineering and Manufacturing" (Springer)
- Editor of the Conference Proceedings, International Conference on Extrusion and Benchmark (ICEB 2009) - "Advances on Hot Extrusion and Simulation of Light Alloys"

Further Memberships

- Turkish-German Cultural Association, Ankara, Turkey
- Advisory Board of the congress trade fair „Proform" 2010, Dortmund
- DAAD Scholar Committee, Ankara, Turkey
- IUTAM - Turkish Branch of the International Union of Theoretical and Applied Mechanics, Turkey
- Member of the Scientific Committee, 10th International Conference on Numerical Methods in Industrial Forming Processes (NUMIFORM 2010), Pohang, Korea
- Member of the International Program Committee, International Conference on Machine Design and Production 2010 (14th UMTIK), Güzelyurt, Northern Cyprus, Turkey

- Member of the International Program Committee, 5th International Conference and Exhibition on Design and Production of Machines and Dies/Molds 2009, Kusadasi, Turkey
- Member of the Scientific Committee, The Swedish Production Symposium (SPS'09) – Focusing on Automotive Manufacturing 2009, Gothenburg, Sweden
- Member of the Scientific Committee, 50th IDRRG Conference 2010, Graz, Austria

Activities as Reviewer

In Scientific Committees

- DFG – German Research Foundation
- Bayerische Forschungsstiftung
- Danish Agency for Science, Technology, and Innovation
- Evaluation Panel of the School of Materials Science & Engineering and Department of Plasticity Forming Engineering, Shanghai Jiao Tong University
- Academy of Finland and the Research Council for Natural Sciences and Engineering
- Foundation for Polish Science

For Journals

- Computer Methods in Applied Mechanics and Engineering (Elsevier)
- Steel Research International (Wiley)
- International Journal of Material Forming (Springer)
- Journal of Materials Processing Technology (Elsevier)
- International Journal of Mechanics of Materials (Elsevier)
- Journal of Simulation Modelling Practice and Theory (Elsevier)
- Steel Grips – Journal of Steel and Related Materials
- Book Review (Wiley)
- Journal of ComputerMethods in Materials Science
- Journal of Computational Materials Science (Elsevier)

For Conferences

- International Aluminium Conference, Düsseldorf, Germany, 2009
- 3rd International Conference on Accuracy in Forming Technology ICAFT, Chemnitz, Germany, 2009
- 7th International Conference on Industrial Tools and Material Processing Technologies - ICIT & MPT 2009, Ljubljana, Slovenia, 2009
- Book-Review (Wiley)
- Journal of Computational Methods in Materials Science
- Journal of Computational Materials Science (Elsevier)

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

Memberships as President of the German Research Foundation and Further Memberships and Cooperation etc.

- Academia Europaea
- acatech – German Academy of Science and Engineering
- Alfred Wegener Institute (Member of the Scientific Advisory Board)
- AGU – Wissenschaftliche Arbeitsgemeinschaft Umformtechnik
- Allianz der Wissenschaftsorganisationen (DFG, FhG, HGF, HRK, MPG, WGL, WR)
- AiF - German Federation of Industrial Research Associations (Curatorship Member)
- AvH – Alexander von Humboldt Foundation (Vice President)
- Berlin-Brandenburgische Akademie der Wissenschaften
- Adviser of Siepmann-Werke GmbH & Co.KG
- Adviser of SimuForm GmbH
- Adviser of Winkelmann Group GmbH & Co. KG
- CIRP – The International Academy for Production Engineering
- COST – European Cooperation in Science and Technology
- German-American Academic Council (Curatorship Member)
- German Academy of Sciences Leopoldina
- German Institute for Japanese Studies (Member of the Advisory Board)
- Deutscher Zukunftspreis (Curatorship Member)
- DLR – German Aerospace Center (Member of the Senate)
- EUROHORCs (Member of the Steering Committee and General Assembly)
- ESF – European Science Foundation
- Fraunhofer Gesellschaft (Member of the Senate)
- Fritz Thyssen Stiftung (Member of the Scientific Advisory Board)
- FOSTA - Research Association for Steel Application (Curatorship Member)
- Helmholtz Association of German Research Centers (Member of the Senate)
- HRK – German Rector's Conference (Permanent Guest)
- MPG – Max Planck Society (Member of the Senate)
- Stifterverband für die Deutsche Wissenschaft (Advisory Member of the Managing Board)
- Werner-von-Siemens-Ring Foundation
- German National Academic Foundation (Curatorship Member)
- Neue Verantwortung Foundation (Curatorship Member)
- Steel Institute VDEh
- VDI – The Association of German Engineers
- Villa Vigoni Association
- WGL – Gottfried Wilhelm Leibniz Scientific Community (Member of the Senate)
- WGP – German Academic Society for Production Engineering
- WiD – Wissenschaft im Dialog (Chairman of the Steering Committee)
- Wissenschaftskolleg zu Berlin – Institute for Advanced Study Berlin
- WPK – Wissenschafts-Pressekonferenz (Curatorship Member)

4 Technical Equipment

4.1 Experimental Area

Presses

- Hydraulic drawing press, 2600 kN, triple action, SMG HZPUI 260/160-1000/1000
- Extrusion press 250t, Collin, PLA250t
- Screw press, 3150 kN, Weingarten PS 180, 3150kN
- C-frame-eccentric press, 630 kN, Schuler PDR 63/250
- Hydraulic drawing press, 1000kN, HYDRAP HPSZK 100-1000/650
- Hydraulic drawing press, 10MN triple action, M+W BZE 1000-30.1.1
- Press for working media based sheet metal forming, 100 MN, SPS
- 10 MN extrusion press, suitable for curved profile extrusion, with short-stroke front loader design, SMS

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 850 D
- Calibration frame, Boxdorf HP-4-2082
- Pressure intensifier, 2000 bar
- Pressure intensifier, 4000bar

- Hydraulic power unit, Bosch 250 L
- Machine for electromagnetic forming, 1,5 kJ, PPT SMU 1500
- 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 100KN
- Universal testing machine, Zwick SMZ250/SN5A
- Compression test machine, IUL 1000 kN

Measurement Technique and Electronics

- 3D-coordinate measurement machine, Zeiss PRISMO VAST 5 HTG
- 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, Aramis - optical measuring systems for geometry and strains
- High-speed camera, HSFC pro of the company PCO Computer Optics GmbH
- Light optical microscope Axio Imger.M1m adapted for polarization with Z-drive, TFT monitor, and high resolution camera AxioCam MRc, Zeiss AG

Miscellaneous

- Laser processing center, Trumpf LASERCELL TLC 1005
- Plastic injection moulding machine, Arburg Allrounder 270 C 400-100

- Roll seam welding machine, Elektro-Schweißtechnik Dresden UN 63 pn
- Turning machine, Weiler Condor VS2
- Universal milling and drilling machine, DMG Hilden DMU 50 T
- Low-pressure beam system , PIT
- Column drilling machine, Alzmetall AB 4/SV
- Plate shear, Durmazlar RGM 2004
- Circular shear, Fasti 501 KS
- Vacuum dryer, Leybold VT5042
- Electric frame saw, Kläger & Müller 4B-200
- 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

4.2 Hardware 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 2007 Professional

- Diverse Adobe products, as for example Photoshop, Freehand, Acrobat, InDesign, Illustrator11, Premiere Pro1.5
- Corel Designer X4

CAD

- Unigraphics
- Catia
- AutoCad
- Mechanical Desktop
- Mathcad
- Matlab

FEM Special Purpose

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

FEM General Purpose

- MARC
- Ansys
- Abaqus
- LS-Dyna