UNIVERSITÄT PADERBORN
Die Universität der Informationsgesellschaft

LTM
Lehrstuhl für Technische Mechanik

24. Workshop
Composite Forschung in der Mechanik
5. Forum Metallplastizität
30. November und 01. Dezember 2011
Paderborn, Liborianum

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DFG Sonderforschungsbereich
Transregio 30

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GRADUATE SCHOOL 1483
Process Chains in Production:
Interaction, Modelling and Assessment of Process Zones

24. Workshop Composite Forschung / 5. Forum Metallplastizität

Vorwort

Wie vor zwei Jahren führen die AG Composite aus Paderborn und Karlsruhe, das Graduiertenkolleg des SFB/TR 30 der Universitäten Kassel, Dortmund und Paderborn sowie das Graduiertenkolleg 1483 der Universität Karlsruhe einen gemeinsamen Workshop zu Werkstoffuntersuchungen durch. Besondere Beachtung finden in diesem Jahr Kunststoffe, deren makroskopisches Materialverhalten aus der Mikrostruktur resultiert. Beispielsweise lassen sich durch Zumischen geeigneter Polymere die Eigenschaften den jeweiligen Bedingungen anpassen. Dazu zählen sowohl Stabilisierungen gegenüber Medieneinflüssen wie Wärme, Licht, Luft und Feuchtigkeit als auch Verstärkungen durch Füllstoffe, insbesondere Glasfasern. Für den diesjährigen Workshop waren Wissenschaftler aus verschiedenen Bereichen aufgefordert, ihre Erkenntnisse zu Werkstoffuntersuchungen für Kunststoffe vorzustellen.

Wie in den Vorjahren werden darüber hinaus aktuelle Fragestellungen zu Metallen unter Berücksichtigung der Mehrskaligkeit behandelt. Dabei stehen Entwicklungen der experimentellen Charakterisierung und der Simulationsmethoden zur Beschreibung, Bewertung und Optimierung von Bauteilzuständen in verketteten Fertigungsprozessen im Vordergrund.

Gemeinsame Workshops mit Wissenschaftlern verschiedener Fachrichtungen haben in der Vergangenheit in Paderborn zu spannenden und aufschlussreichen Diskussionen geführt, auf die wir uns auf Grund der interessanten eingereichten Beiträge auch in diesem Jahr freuen dürfen.

T. Böhlke, O. Wünsch, B. Nestler, V. Schulze, R. Mahnken

Ermöglicht durch die freundliche Unterstützung
des DFG-Sonderforschungsbereichs
Transregio 30

24. Workshop Composite Forschung / 5. Forum Metallplastizität

Ein gemeinsamer Workshop des DFG Graduiertenkollegs 1483

und des DFG Sonderforschungsbereiches Transregio 30

Programm

Mittwoch, 30. November 2011

9:00 Eröffnung

Kunststoffe: Experimente
Chairman: Mahnken

09:05-09:35 **V. Schöppner, A. Wibbeke, M. Sasse:** Manufacture of self-strengthened Polycarbonate by extrusion

09:35-10:05 **B. Brylka, T. Böhlke:** DMA measurement on discontinuous glass fibre reinforced thermoplastics

10:05-10:35 **H.-P. Heim, A. Ries, B. Rohde:** Thermo-mechanical Compression Moulding of Self-reinforced Polypropylene Composites

10:35-11:00 Kaffeepause

Kunststoffe: Experimente und Modellierung
Chairman: Wünsch

11:00-11:40 **S. Kolling, S. Mönnich, R. Glöckner:** Nichtlineare Berechnungen von Bauteilen aus kurzglasfaser-verstärkten Kunststoffen unter stossartiger Belastung

11:40-12:10 **N. Nörenberg, R. Mahnken:** A stochastic model for the direct and the inverse problem of adhesive materials

12:10 Gruppenfoto

12:30-13:45 Mittagessen

Kunststoffe: Faserverbunde
Chairman: Kolling

13:45-14:15 **F. Hankeln, R. Mahnken:** Carbon fibre prepregs, simulation of a thermal-chemical-mechanical-coupled problem

14:15-14:45 **J.-W. Simon, D. Sodhani, B. Stier, J. Wimmer:** Experimental and numerical analysis of FIBRE composite failure

14:45-15:15 **P. Starke, Ch. Alter, F. Mayer, S. Kolling, H. Altenbach:** Vorschlag einer Versagensfläche für unidirektionale Faserverbunde unter mehrachsiger Belastung

15:15-15:45 Kaffeepause

Kunststoffe: Simulation und Prozesse
Chairman: Caylak

15:45-16:15 **Ammar Al-Baldawi, Olaf Wünsch:** Numerical simulation of the polymeric matrix of a composite material using DEVSS and dynamic mesh methods

16:15-16:45 **E. Moritzer, T. Plugge:** Simulation of the GITBlow process based on the finite element method

19:00 Abendessen im Liborianum

Donnerstag, 01. Dezember 2011

Metalle: Mikromechanische Modelle
Chairman Klusemann

09:00-09:30 **R. Ostwald, T. Bartel, A. Menzel:** Mikromechanisch motivierte Modellierung und Simulation der temperaturabhängigen Interaktionen zwischen Phasentransformationen und Plastizität

09:30-10:00 **V. Glavas, T. Böhlke, D. Daniel and C. Leppin:** Two scale simulation of a multi-step can forming process

10:00-10:30 **M.J. Holzweißig, D. Canadinc, H.J. Maier:** In-situ characterization of transformation plasticity in an isothermal austenite-to-bainite phase transformation

10:30-10:55 Kaffeepause

Metalle: Simulation und Prozesse
Chairman Böhlke

10:55-11:25 **B. Klusemann, B. Svendsen:** Thermodynamic modelling and simulation of inelasticity and stress relaxation in metallic materials via strain gradient plasticity and non-convexity

11:25-11:55 **D. Schneider, J. Höhn, M. Selzer, A. Vondrous, B. Nestler:** Modeling of elasto-plastic material behaviour with the phase-field method

11:55-12:25 **M. Senn, N. Link:** Generic process observers

12:25 Abschlussworte

12:30-13:30 Mittagessen

ABSTRACTS

NUMERICAL SIMULATION OF THE POLYMERIC MATRIX OF A COMPOSITE MATERIAL USING DEVSS AND DYNAMIC MESH METHODS

Ammar Al-Baldawi, Olaf Wünsch

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Abstract

Polymeric composites can be obtained using a pressing process. Fibers and the surrounding matrix are squeezed under high pressure, deformation rates and temperatures. However, under these aspects the matrix is a non-Newtonian polymermelt with shear thinning, elongation hardening and elastic properties. The classical way to model such melts is a generalized Newtonian viscosity model, like the so-called Cross-Power law. Using this model satisfy the shear thinning behavior but completely neglect the elongation and elastic properties. This problem is carried out in this work with a macroscopic ansatz, the generalized Maxwell model. Here, the Giesekus anisotropic mobility tensor is used to include elongation hardening and relaxation phenomena [1]. These models lead to a set of hyperbolic equations for continuity, momentum and material model. Therefore, we use the DEVSS method to make sure that the elliptic behavior is still the dominating property [2].
For the numerical simulation of the pressing process with regard to the molten matrix we discretize the equation set with the finite volume method. The ALE formulation in connection with a dynamic mesh is used to move the boundary region of the squeezer inside the Euler space, see Fig 1. The dynamic mesh is generated with a cell-layering method. This method leads to topological changes in the mesh during the simulation time. In the present work we demonstrate some Newtonian and Non-Newtonian (with elasticity) simulations. Fig. 1 shows the numerical model with elliptical rigid fibers and the surrounding matrix squeezed by two parallel plates. For different time steps the cell generation and destruction and the velocity magnitude is visualized. Note the new generated cells during the simulation are coarse to speed up the calculation speed.

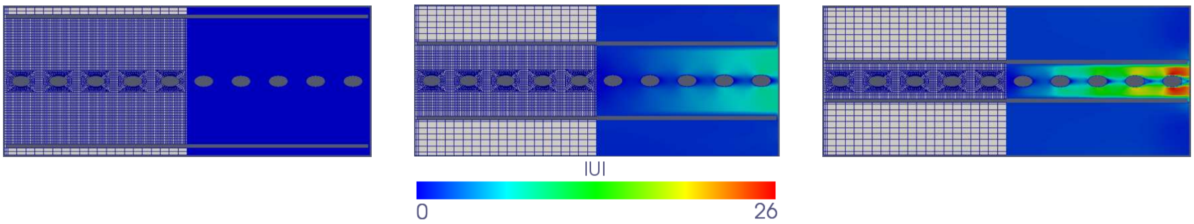

Fig. 1 mesh and velocity field of a generalized Non-Newtonian melt in a pressing process, where to squeezers are pressing the molten matrix around the solid fibers.

Literatur

[1] O. Wünsch, IJEMFS, 1-4, p. 255-267 (2009)
[2] N. Cardozo et. al, 10th I. Symposium on Process Engineering, p. 915-920. (2009)

ANISOTROPIC BEHAVIOUR OF DC04 STEEL

M. Baiker[1,2], D. Helm[1]

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[2] Institute of Applied Materials Reliability of Components and Systems IAM-ZBS

Abstract

The ferritic DC04 steel is a common material for forming processes. In sheet metal forming the material is subjected to finite deformations and complex loading paths. The simulation of complex forming processes requires material models that combine good predictions of the material behaviour with fast performance and robustness. Therefore, the simulations are typically based on phenomenological models as stated for example by Chaboche and Rousellier [1], Barlat and Lian [2] or Krasovskyy [3]. A great variety of material models exist. In industrial environment a common approach to model the anisotropy of sheet metal is to use a Hill type yield function [4]. In this work we investigate whether it is possible to model the anisotropic behaviour of DC04 steel with this approach properly. Besides the experimental results, simulations on the microscale based on crystal plasticity methods are performed to detect additional points on the initial yield surface. The information about the shape of the initial yield surface can is used to calibrate the macroscopic model and is compared to the shape of the Hill type yield surface calibrated to the Lankford coefficients. To identify the capability and limitations of the phenomenological model tension tests in seven directions are simulated. The resulting stress strain curves as well as the derived Lankford coefficients are compared to experimentally determined data.

Literature

[1] Chaboche, J.L., Rousselier, G., 1983. On the plastic and viscoplastic constitutive equations – Part I. Rules developed with internal variable concept, J. Press. Vess. Technol. ASME, 105, p. 153-158.

[2] Barlat, F., Lian, J., 1989. Plastic behavior and stretchability of sheet metals. Part I: A yield function for orthotropic sheets under plane stress conditions, International Journal of Plasticity 5, p. 51-66.

[3] Krasovskyy, A., Schmitt, W., Riedel, H., 2006. Material Characterisation for Reliable and Efficient Springback Prediction in Sheet Metal Forming, Steel Research Int. 77, No. 9-10, p. 747- 753.

[4] Hill, R., 1948. A Theory of the Yielding and Plastic Flow of Anisotropic Metals, Proceedings of the Royal Society of London, 193A, p. 281.

SIMULATION OF MICROSTRUCTURE EVOLUTION DURING COLD ROLLING OF A DC04 STEEL

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Abstract

The development of steel grades for the automotive industry is based on substantiated knowledge about the microstructure and the deformation mechanisms of existing materials. As these characteristics and the material properties change strongly during the production process. One approach to further investigate the evolution of the material properties is to simulate the process steps on the microscale. In this work one part of the process chain in sheet metal forming, the cold rolling process, is investigated. During the cold rolling process the microstructure of the material evolves strongly. That leads to major changes in the macroscopic material properties. It is hardly possible to describe microstructure evolution with classical models. Therefore, the cold rolling process is simulated based on crystal plasticity models. Close-to-reality grain structures are generated to a representative volume element treated in the context of the finite elements, in order to represent the microstructure of the material and to consider a spatial distribution of the individual grains. Texture information from EBSD measurements are reduced to the number of grains considered in the simulation and mapped to the created microstructure. The texture and morphology after the rolling process are compared to experimental results. Additionally the macroscopic material response of the deformed material is investigated simulating uniaxial tension tests and comparing the results to measured stress strain data.

DMA MEASUREMENT ON DISCONTINUOUS GLASS FIBRE REINFORCED THERMOPLASTICS

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Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany

Abstract

In the automotive applications short and long glass fibre reinforced thermoplastics are commonly used for nonstructural parts. Due the versatile possibilities of manufacturing, forming, joining and recycling, thermoplastic matrix based composites are increasingly used also for semistructural parts. Thermoplastics like e.g. polypropylene show a high temperature and strain-rate dependence. Therefore, for the automotive application sector material models for a wide range of strain rates and temperatures are needed. Additionally, the influence of the viscoelastic behaviour of the matrix material on the effective material behaviour of the composite is of high interest.

The DMA technique is an effective method to investigate the elastic and viscoelastic stiffness response of materials under cyclic loading. After a short introduction into the DMA technique results for polypropylene and polypropylene based composite material will be presented. The composite under consideration is an long glass fibre reinforced thermoplastic manufactured in compression moulding. This manufacturing process induces an anisotropic fibre distribution and for that reason the effective properties as well as the temperature and strain rate dependency has been investigated in an anisotropic manner. The comparison of the elastic and visocelastic material response of the matrix and the composite will be discussed in detail.

Literatur

[1] Middendorf, P.: Viskoelastisches Verhalten von Polymersystemen. Fortschritt-Berichte VDI, Reihe 5, VDI Verlag.

[2] Deng, S., Hou, M., Ye, L.: Temperature-dependent elastic moduli of epoxies measured by DMA and their correlations to mechanical testing data. Polymer Testing 26 (2007) 803–813

[3] Kontou, E., Kallimanis, A.: Thermo-visco-plastic behaviour of fibre-reinforced polymer composites. Composites Science and Technology 66 (2006) 1588–1596.

TWO SCALE SIMULATION OF A MULTI-STEP CAN FORMING PROCESS

V. Glavas[a], T. Böhlke[b], D. Daniel[c] and C. Leppin[d]

[a,b]Karlsruhe Institute of Technology (KIT),
[c]Constellium Research Center, [d]Suisse Technology Partners AG

Abstract

Aluminum sheets show a significant anisotropic plastic material behavior in metal forming operations. E.g., in a deep drawing process of cups this anisotropy leads to a non-uniform height, i.e., an earing profile. The prediction of earing profiles is very important for the optimization of the forming process. In most cases the earing behavior can not be precisely predicted based on phenomenological material models. In the presentation a micromechanical, texture-based model is used to simulate the first two steps (cupping and redrawing) of a can forming process. The predictions of the earing profile after each step are compared to experimental data.

The mechanical modeling is based on a large strain elastic visco-plastic crystal plasticity material model with Norton type hardening and a Taylor type homogenization scheme. The simulations are carried out in the framework of the finite element method. Texture information and flow curves for uniaxial tensile tests in different directions relative to the rolling direction are used to identify the material parameters. The simulations are carried out for different friction coefficients, blank-holder forces and several mesh mesh-densities. The finite elment based earing profiles are compared to both experimental data and predictions of simple analytic models.

Literature

[1] Gao, X., Przybyla, C., Adams, B., 2006. Methodology for Recovering and Analyzing Two-Point Pair Correlation Functions in Polycrystalline Materials. Metallurgical and Materials Transactions A 37A, 2386–2387.

[2] Jöchen, K., Böhlke, T., 2011. Preprocessing of Texture Data for an Efficient Use in Homogenization Schemes. Proceedings of ICTP 2011 .

[3] Böhlke, T., Risy, G., Bertram, A., 2005. A texture component model for anisoropic polycrystal plasticity. Computational Material Science 33, 284-293.

[4] Böhlke, T., Risy, G., Bertram, A., 2006. Finite element simulation of metal forming operations with texture based material models. Modelling and Simulation in Material Science and Engineering. 365-387.

CARBON FIBRE PREPREGS, SIMULATION OF A THERMAL-CHEMICAL-MECHANICAL-COUPLED PROBLEM

F. Hankeln, R. Mahnken

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Abstract

In automotive industry research is done to replace high strength steel by combinations of steel and carbon-fibre prepregs (pre-impregnated fibres). It is planned to form both steel and uncured prepregs in one step followed by the curing process under pressure in the forming die [1]. The ability to simulate the mechanical behaviour during forming and curing would allow more economical processes.

The simulation of prepregs must regard highly anisotropic, viscoelastic and thermal-chemical properties. For this the model is split into an anisotropic elastic part, which represents the fibre fraction and an isotropic, viscoelastic part, representing the matrix. This part also contains curing, causing a dependency on time and temperature.

During deep-drawing large deformations are occurring, so a large strain model regarding anisotropy[2], viscoelasticity [3] and curing [4] has been developed. Also experiments were made to evaluate this model. Current progress ist the exact identification of material parameters.

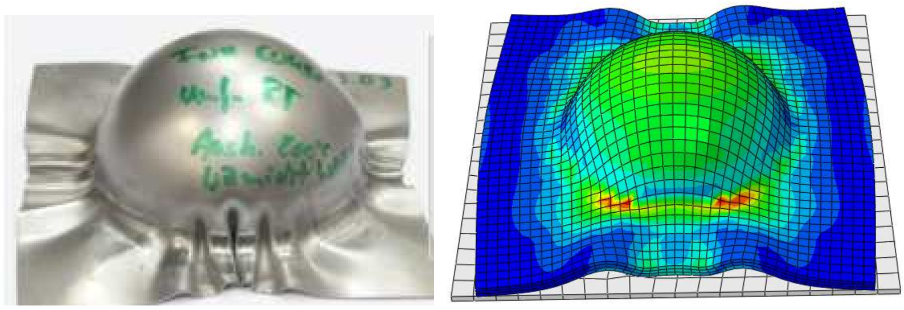

Fig. 1 Experiment and simulation of deep drawing a combination of steel and prepreg

Literature

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[3] Tschoegl, N.W. “The Phenomenologial Theory of Linear Viscoelastic Behaviour”, Springer Verlag, 1989

[4] Lion, A. and Höfer, P., “On the phenomenological representation of curing phenomena in continuum mechanics”, Arch. Mech. 59, 2007

IN-SITU CHARACTERIZATION OF TRANSFORMATION PLASTICITY IN AN ISOTHERMAL AUSTENITE-TO-BAINITE PHASE TRANSFORMATION

M.J. Holzweißig[1], D. Canadinc[2], H.J. Maier[1]

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Abstract

This work elucidates the stress-induced variant selection process during the isothermal austenite-to-bainite phase transformation in a tool steel. Specifically, a thorough set of experiments combining electron backscatter diffraction and in-situ digital image correlation (DIC) was carried out to establish the role of superimposed stress level on the evolution of transformation plasticity (TP) strains during phase transformation. The important finding is that TP increases concomitant with the superimposed level, and strain localization accompanies phase transformation at all stress levels considered. Furthermore, TP strain distribution within the whole material becomes more homogeneous as the superimposed stress level increases such that fewer bainitic variants are selected under higher stresses and grow to yield a more homogenous stress distribution. In particular, the [101]- and [201]-oriented bainitic variants were associated with large TP strains upon phase transformation. Overall, this very first in-situ DIC investigation of the austenite-to-bainite phase transformation in steels evidences the clear relationship between the superimposed stress level, variant selection and evolution of TP strains.

THERMODYNAMIC MODELING AND SIMULATION OF INELASTICITY AND STRESS RELAXATION IN METALLIC MATERIALS VIA STRAIN GRADIENT PLASTICITY AND NON-CONVEXITY

B. Klusemann, B. Svendsen

Material Mechanics, RWTH Aachen University

Abstract

During loading of real (i.e., materially heterogeneous) metallic materials, local microscopic stress concentration activates individual microscopic defects (e.g., dislocations) in the material, resulting in local stress relaxation. In general, this will take place in the material "long" before the macroscopic activation or yield threshold is reached.

Only when a sufficient "critical" number of such defects are activated, do they collectively breakthrough to the macroscopic level, resulting in macroscopic yield and macroscopic stress relaxation. As is well-known, one way to model such emergent behavior in many physical systems and contexts is with the help of phase-field methods and non-convexity. Several sources of non-convexity are known in material science, e.g., dislocation-lattice interaction, glide-system interaction or large deformation. As very simple non-convex energy forms we examine polynomial-based Landau-Devonshire type forms such as that examined recently by Yalcinkaya et al.[1], as well as periodic forms such as the Frenkel form as shown in Fig. 1.

The purpose of this work is the modeling of the transition from elastic to inelastic material behavior and the concomitant stress relaxation via energetic non-convexity. To this end, a model formulation based on continuum thermodynamics and rate-variational methods is presented.

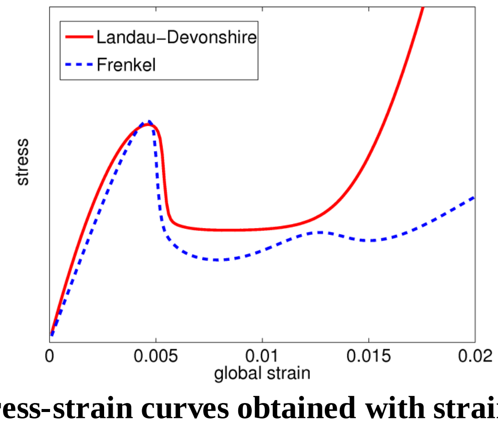

Fig. 1 Comparison of stress-strain curves obtained with strain gradient model for two different non-convex energy forms.

Literatur

[1] T. Yalcinkaya, W. Brekelmans, M. Geers, “Deformation patterning driven by rate dependent non-convex strain gradient plasticity”, Journal of the Mechanics and Physics of Solids 59 (1) (2011) pp. 1–17.

NICHTLINEARE BERECHNUNGEN VON BAUTEILEN AUS KURZGLASFASER-VERSTÄRKTEN KUNSTSTOFFEN UNTER STOSSARTIGER BELASTUNG

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Abstract

Im Rahmen des Beitrags werden die mit der Berechnung von Strukturbauteilen aus kurzglasfaserverstärkten Kunststoffen einhergehenden Probleme diskutiert und mögliche Lösungen vorgeschlagen. Zunächst werden am Beispiel eines glasfaserverstärkten Polyamids die Einflussgrößen auf die lokalen mechanischen Werkstoffeigenschaften gezeigt (Abb. 1 links zeigt die lokale Dehnungsmessung in einem Zugversuch). Anhand der experimentell ermittelten Anisotropie des Werkstoffes wird dann ein rein phänomenologisches transversalisotropes visko-plastisches Materialgesetz formuliert. Die Strategie zur Parameteridentifizierung wird anhand eines PA6GF60 gezeigt.
Eine Alternative zur phänomenologischen Modellierung bietet der mikromechanische Zugang. Auf Basis von lokal bekannten Orientierungsverteilungen der Glasfasern kann über Homogenisierungsverfahren aus den Eigenschaften von Glasfasern und Polymermatrix die makroskopische Materialantwort berechnet werden.
Die Güte solcher Verfahren hängt direkt von der berechneten Glasfaserorientierung ab. Problempunkt bei der Simulation eines realen Strukturbauteils über mikromechanische Modelle ist somit die Erfassung des Spritzgussvorgangs und die damit verbundene Orientierungsverteilung der einzelnen Glasfasern. Über eine neu entwickelte Auswertemethode einer lokalen µCT-Messung wird die Güte von solchen Spritzgusssimulationen diskutiert. Die experimentelle Bestimmung der Glasfaserorientierung und der Faserlängenverteilung erfolgt über das Röntgenbild der µCT vermittels einer Monte Carlo Bildwerterkennung (Abb.1 rechts: 3D Fasererkennung), welche im Rahmen des Beitrages vorgestellt wird.

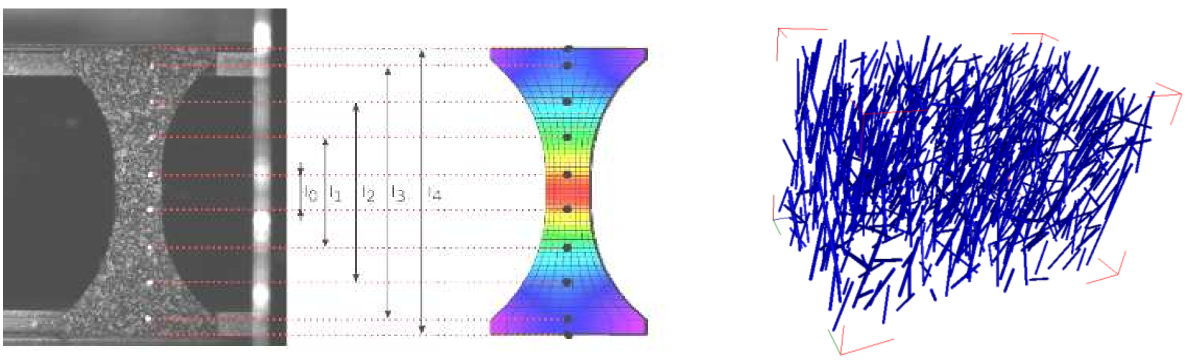

Abb. 1 Lokale Dehnungsmessung im Zugversuch und Fasererkennung

A STOCHASTIC MODEL FOR THE DIRECT AND THE INVERSE PROBLEM OF ADHESIVE MATERIALS

N. Nörenberg, R. Mahnken

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Abstract

This work deals with the generation of artificial data [1] based on experimental data for adhesive materials and the application of this data to the inverse and the direct problem. In reality there are only a very limited number of experimental data available. Therefore, the prediction of material behaviour is difficult and a statistical analysis with a stochastic proved thesis is nearly impossible. In order to increase the number of tests a method of stochastic simulation based on time series analysis [2] is applied,. With artificial data an arbitrary number of data is available and the process of the parameter identification can be statistically analysed. Additionally, two examples are shown, which adapt the analysed material parameter to the direct problem see figure 1. The stochastic finite element method [3] is used to take into account the distribution and deviation of the fracture strain.

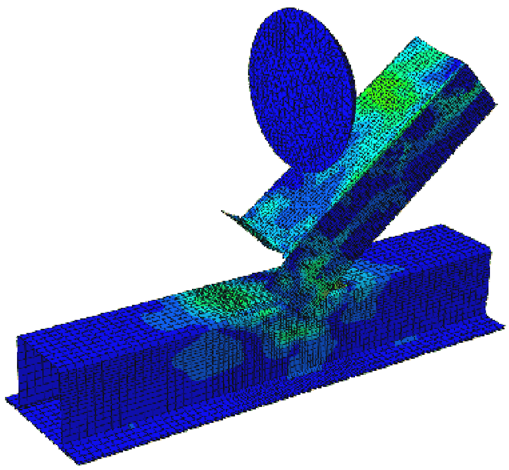

Abb. 1 T-joint with side impact

Literatur

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MIKROMECHANISCH MOTIVIERTE MODELLIERUNG UND SIMULATION DER TEMPERATURABHÄNGIGEN INTERAKTIONEN ZWISCHEN PHASENTRANSFORMATIONEN UND PLASTIZITÄT

***R. Ostwald*[1]*, T. Bartel*[1]*, A. Menzel*[1,2]**

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[2] Lund University, Division of Solid Mechanics

Abstract

Wir präsentieren einen neuartigen Ansatz zur effizienten Modellierung und Simulation der Interaktionen zwischen Phasentransformationen und Plastizität in Festkörpern. Dazu wird jeder betrachteten Materialphase ein thermo-elasto-plastisches Helmholtz-Potential zugeordnet. Das verwendete Modell erlaubt die Berücksichtigung einer beliebigen Anzahl an Phasen; wir beschränken uns jedoch auf die austenitische Ausgangsphase sowie je eine martensitische Zug- und Druckphase.
Die Evolution der Volumenfraktionen bestimmen wir basierend auf einem Ansatz aus der statistischen Physik, wo Transformationswahrscheinlichkeiten in ein nichtlineares Differentialgleichungssystem zur Bestimmung der zeitlichen Volumenfraktionsentwicklung eingehen.
Für die Plastizität berücksichtigen wir eine von-Mises-Fließfunktion mit dehnungsproportionaler Materialverfestigung. Die gekoppelten Evolutionsgleichungssysteme werden nicht-monolithisch gelöst, wobei inkrementelle Änderungen plastischer Versetzungsdichten aufgrund von Volumenfraktionsevolution zusätzlich durch ein physikalisch motiviertes Vererbungsgesetz für plastische Dehnungen berücksichtigt werden [1]. Zur Lösung dreidimensionaler Randwertprobleme wird das Modell schließlich in eine Microsphere-Formulierung eingebettet.

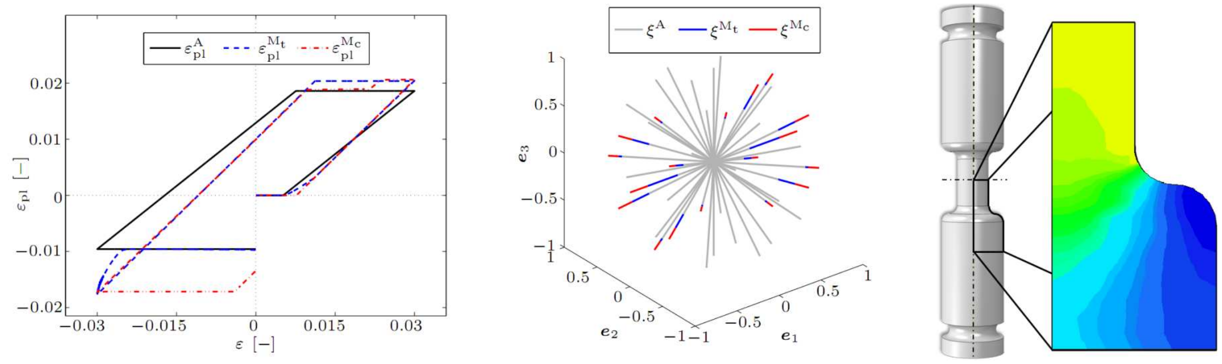

Abb. 1 Evolution plastischer Dehnungen, räumliche Phasenverteilung, FE-Beispiel [2].

Literatur

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SIMULATION OF THE GITBLOW PROCESS BASED ON THE FINITE ELEMENT METHOD

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[1] Polymer Engineering Paderborn, University of Paderborn

Abstract

As the name indicates, the GITBlow process combines the two established processes of gas injection technique (GIT) and blow molding "inline", i.e. integrated in the injection molding process. In the process a second stage inflates the hollow-area of the GIT-Preform by further gas-injection. It thus enables complex plastic parts to be produced with functional hollow areas. The technical demands on the functional hollow areas are based on their practical application, e.g. when used as tank components or pressure tanks. Wall thickness homogeneity is of major importance here to guarantee uniform strength of the hollow space geometry.

In this contribution, a simulation of the GITBlow process is carried out based on the finite element method. The simulation maps the temperature distribution of the preform over a representative cross section for the basic process stages. The results on temperature distribution generated by the simulation are subsequently verified with thermal experimental findings. By dint of this verification it is possible to predict the wall thickness homogeneity of the finished part.

For future development work, the integration of a variothermal process control is simulated in order to screen optimising effects on the temperature and resulting wall thickness distribution.

Finally, a further development based on the GITBlow-technique is shown. The focus of this development, called GRIPBlow, is the production of partially reinforced polymeric support structures.

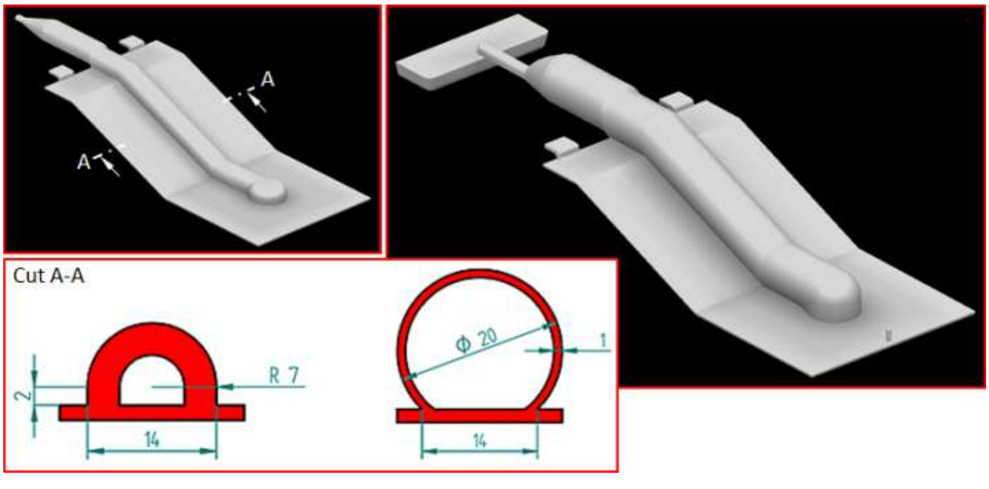

Fig. 1 GITBlow prototype part (left side: preform; right side: finished GITBlow part)

THERMO-MECHANICAL COMPRESSION MOULDING OF SELF-REINFORCED POLYPROPYLENE COMPOSITES

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Abstract

The self-reinforcement of polymer materials is based on a melt and / or a solid phase deformation on the macromolecular level, which systematically influences the crystalline structures in the polymer [1]. One essential special feature of self-reinforced composites materials is founded in the mono-material character. Due to the fact that an additional implementation of foreign fibres, such as glass or carbon fibres, is not necessary, these self-reinforced composites display an exceptional recycling behaviour. This means that highly stretched tapes or fibres made principally out of PP are embedded in an identical matrix system, thus forming the reinforcement phase. Composite manufacture is carried out with layered textiles using a hot press method [2]. By specifically varying the local processing temperature and pressure [3] an effective gradation is generated area-dependent on the composite surface in a one-step-process in a modified forming tool. As a result of mechanical examinations of graded composites, property changes within the composite become visible [4]. In the context of this contribution, we would like to discuss the influence of the processing conditions on self-reinforced polypropylene composites especially into account of the thermo-mechanically gradation.

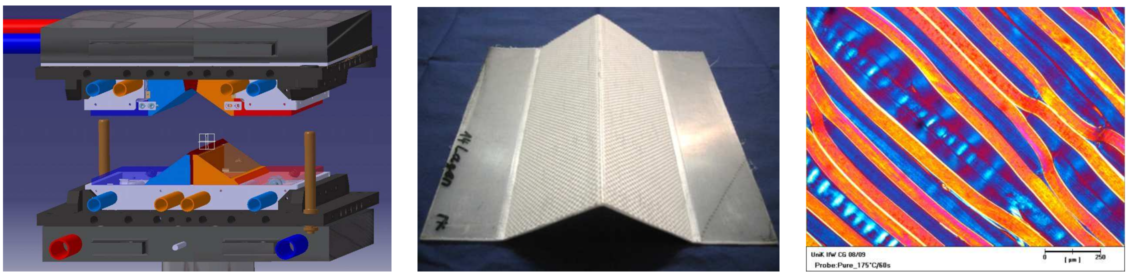

Fig. 1: Modular Forming and Gradation Tool, Graded Composite, Morphology of Consolidated PP-Composite in Polarised Transmitted Light

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MODELING OF ELAST-PLASTIC MATERIAL BEHAVIOUR WITH THE PHASE-FIELD METHOD

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Abstract

An extended phase-field model is formulated incorporating a formulation for elastic and plastic effects on the evolution of microstructure. Thereby, the displacement field is computed by solving the local momentum balance dynamically. In order to calculate the plastic strain, the Prandtl-Reuss model was implemented consisting of an associated flow rule in combination with the von Mises yield criterion and a linear isotropic hardening approximation.

We show simulated stress profiles around elliptical cracks under tensile stress (purely elastic) and compare them to the theoretical predicted stress fields. Simulations with simple loads were performed illustrating the dynamic evolution of the stress and plastic strain using a radial return mapping algorithm in both, single phase system as well as polycrystalline structures. Further we present simulations of micro crack propagation induced by external stresses with and without plastic strain.

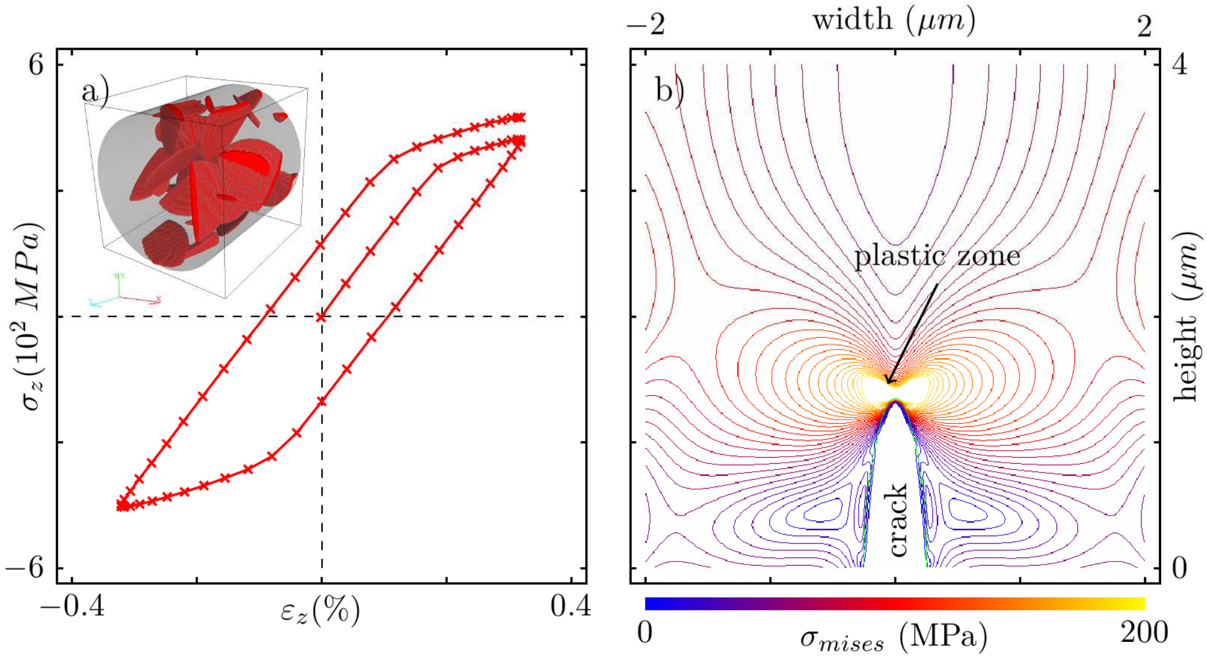

Fig. 1 a) Strain stress curve of an polycrystalline material under cyclic load. b) Plastic zone on the crack tip. [1]

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GENERIC PROCESS OBSERVERS

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Abstract

The modeling of entire process chains allows a holistic view of workpieces from pre-products to end-products under consideration of process interactions. The process parameters of the individual processes can then be adjusted with respect to their associated effort and the desired workpiece properties of the end-product. Therefore, fast process observers that describe only the process characteristics by means of a compact feature space are needed. The extracted features can be used as a basis for process control to find the optimal process parameters for an individual process.

In our work, the monitoring of processes is realized by identifying the generic functional dependencies of state variables which are not accessible during process execution ("hidden state") on related observable quantities. The generic observer model can be instantiated for different processes by adequate selection of observable quantities and related state variables. The revealing of the functional dependencies is realized by statistical learning methods for regression. Dimension reduction methods are applied to regression input and output to reduce the complexity in the regression relation, yielding the compact process characteristics in the feature space. These characteristics can then be used as a basis for an efficient process control according to Bellman's Principle of Optimality by Dynamic Programming [1], which reduces the complexity in breaking up the entire complex problem into smaller sub problems of overlapping time steps.

Hidden state observation for a deep drawing process is implemented by means of Artificial Neural Networks for nonlinear regression and Principal Component Analysis for dimension reduction [2]. The process characteristics of a resistance spot welding process are extracted by Nonlinear Curve Fitting and are used to predict the workpiece properties by Partial Least Squares Regression with integrated dimension reduction [3]. The benefits of these two approaches are then combined into a Principal Function Approximator which enables a nonlinear function approximation with integrated dimension reduction by means of Bottleneck Neural Networks [4].

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EXPERIMENTAL AND NUMERICAL ANALYSIS OF FIBRE COMPOSITE FAILURE

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Abstract

Failure analysis of fibre composite materials is cumbersome, since the stress-strain behavior is highly non-linear and anisotropic.

In order to predict failure in composites, we have set up a nondestructive testing method using a state-of-the-art optical metrology system. Using this, we are able to detect delaminated areas and the onset of (in plane) matrix failure.

In order to capture this complex constitutive behavior, we use a micromechanically motivated continuum model, which represents the fibre directions using the concept of structural tensors. In conjunction with finite element simulations we can accurately predict the stress distribution in the thickness direction and gain a better understanding of inter-layer crack initiation.

For the thin structures considered here, the application of classical solid elements becomes computationally expensive for an accurate prediction of the stress distribution. To overcome this problem, we use the solid-shell concept, which exhibits a highly satisfactory performance in thin shell applications. The solid-shell element possesses the advantages of solid elements displaying realistically the three-dimensional geometry and enabling the definition of surface friction. At the same time, they provide the suitable shape for thin structures in accordance to shell elements.

In addition, the use of the solid-shell formulation allows for an arbitrary number of Gauss points over the shell thickness. Since the material parameters can be defined for each Gauss point separately, different fibre orientations of the layers can easily be handled. Furthermore, this solid-shell formulation removes volumetric locking as well as membrane and thickness locking. Using the assumed natural strain concept (ANS), the transverse shear and curvature thickness locking are cured. Finally, reduced integration has been implemented together with hourglass stabilization, leading to high computational efficiency.

VORSCHLAG EINER VERSAGENSFLÄCHE FÜR UNIDIREKTIONALE FASERVERBUNDE UNTER MEHRACHSIGER BELASTUNG

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Abstract

Trotz inzwischen jahrzehntelanger Verwendung von Faserverbundwerkstoffen sind öffentlich zugängliche Daten für das Versagensverhalten unter mehrachsiger Belastung kaum verfügbar. Auch die im Rahmen von [1] veröffentlichten Werte sind teilweise diskussionswürdig. Neuere Materialmodelle wie das von Cuntze [1] oder Puck [2] stützen sich daher in weiten Bereichen ihrer Gültigkeit auf rein theoretische Überlegungen.

Auf Grundlage von eher anschaulichen Überlegungen wird für die UD – Einzelschicht eine Arbeitshypothese zur ertragbaren Schubspannung τ21 in Abhängigkeit von der Normalspannung in Faserrichtung σ11 aufgestellt. Mit Hilfe dieser Annahme wird das Modell von Puck für das Verhalten der UD – Schicht unter kombinierter Normalspannung quer zur Faser σ22 sowie Schubspannung τ21 erweitert. Die Versagensfläche, die sich aus dieser Erweiterung ergibt, wird mit den ins Materialkoordinatensystem transformierten Festigkeiten von Lee [3] verglichen. Daneben wird auch kurz eine Erweiterung der Versagensfläche beschrieben, die diese Effekte abdecken kann.

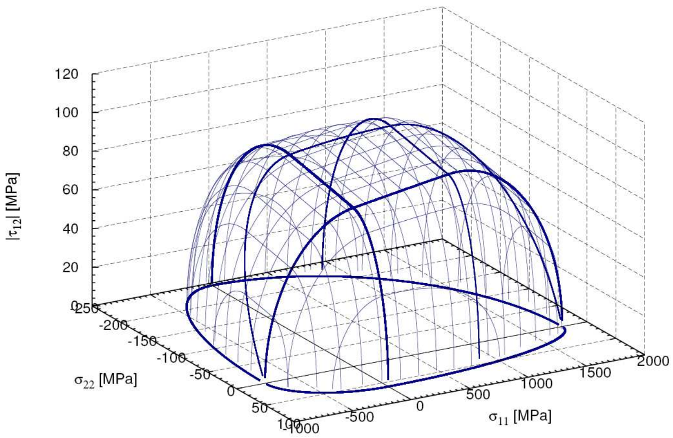

Abb. 1 Vorgeschlagene Versagensfläche

Abschließend wird der Stand der Arbeiten zur Verifikation und Validierung einer Implementierung der Versagensfläche als Benutzer definiertes Model in LS – DYNA dargestellt.

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MANUFACTURE OF SELF-STRENGTHENED POLYCARBONATE BY EXTRUSION

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Abstract

In many oriented materials such as polypropylene and polyethylene the increase in strength of the semi-crystalline phase by elongation is already exploited [1]. The same principle is used as well for the amorphous polymer Polycarbonate. Films or filaments made of stretchable, high molecular, linear Polycarbonate can be orientated by means of stretching such that specific properties are significantly improved. The orientation of the molecular structure and the upward gradient of secondary valence forces cause as well an increase of stiffness and Young's modulus [2]. Prior to orientation, Polycarbonate already has a high strength and impact resistance and, for this reason, further increases due to orientation would disclose an extraordinarily high application potential [2]. In our current work, we focus on films. Polycarbonate films were oriented by a uniaxial stretching line at temperatures just above the glass temperature of 145 ℃ [3]. The relevant process parameters include the temperature during the film's stretching, the level of stretching, the strain rate and the film's thickness.

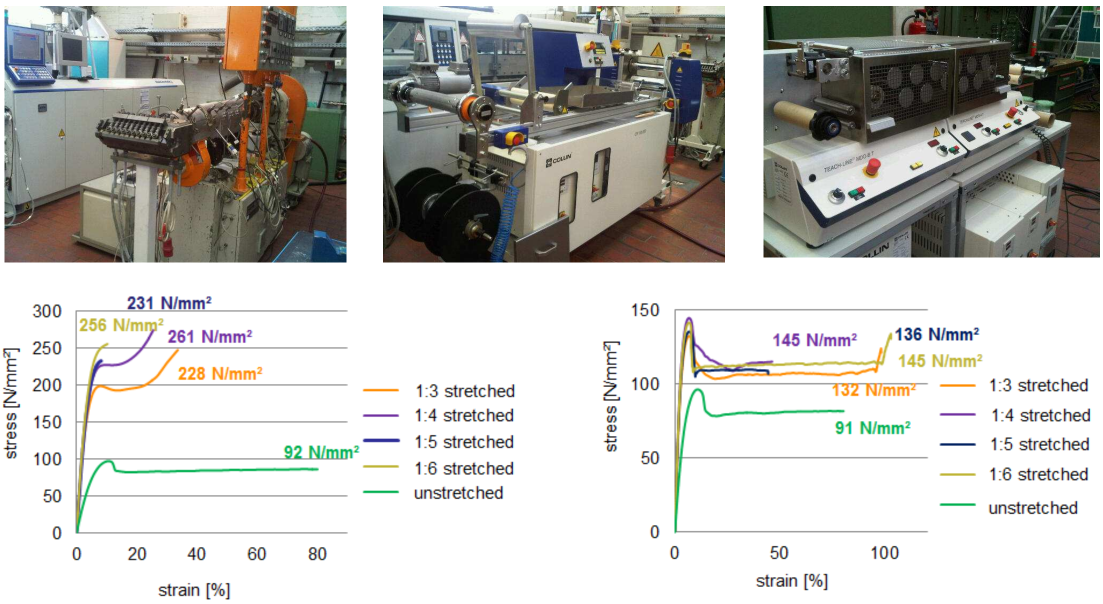

Fig. 1 Manufacture of self-strengthened Polycarbonate and increase in strength by elongation

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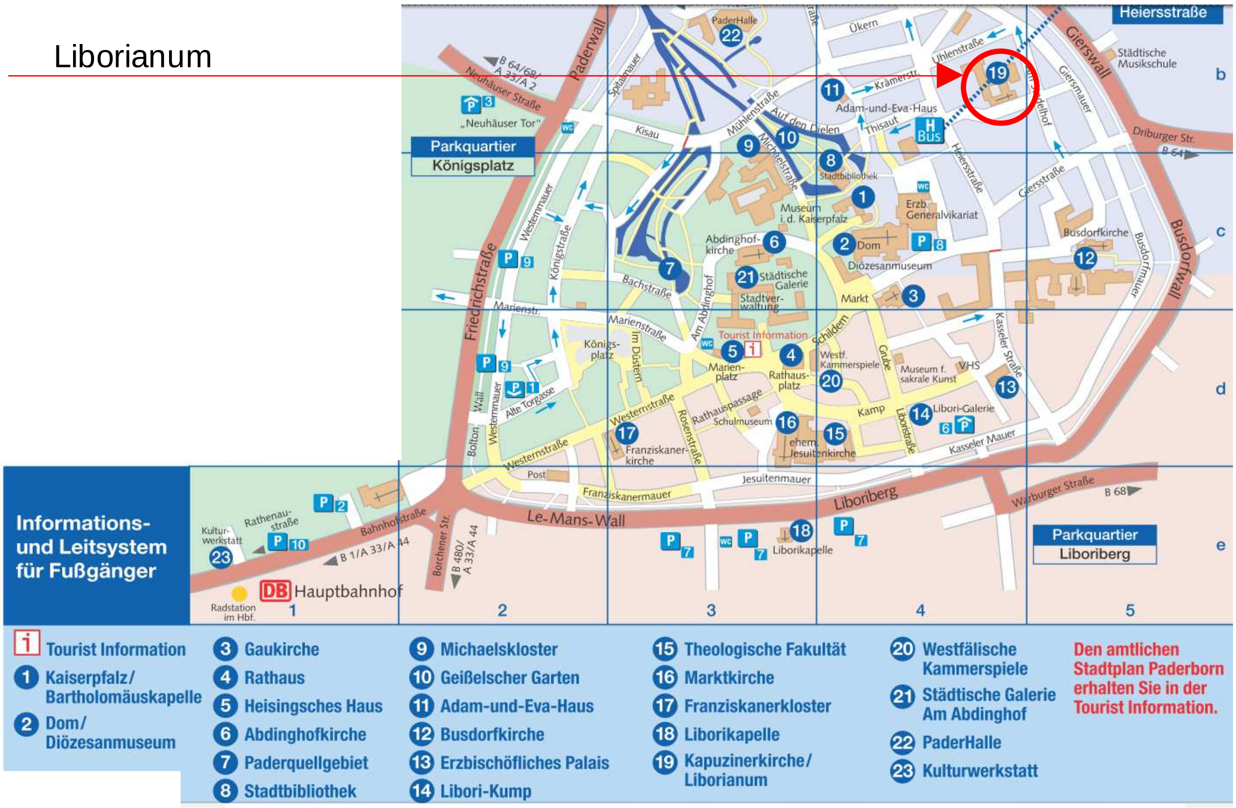

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