Advanced Technology of Plasticity 1987

Proceedings of the Second International Conference on Technology of Plasticity
Stuttgart, August 24/28, 1987

Edited by K. Lange
for Arbeitsgemeinschaft Umformtechnik

Volume I

Springer-Verlag Berlin Heidelberg New York
London Paris Tokyo 1987
# TABLE OF CONTENTS

## Volume I

### Opening Address
- Machine Tools and Flexible Manufacturing
  - Systems State of the Art and Outlook to the Future
  - B. Leibinger
  - XVII

- Steels for Engineering Applications
  - Present State and Trends
  - H. J. Engell
  - XXI

- Development Trends in Bodywork Manufacture with the Focus on
  - New Technologies and Materials
  - W. Jacobi
  - XXXI

### Papers

#### Fundamentals: Bulk Forming

- **Keynote Paper:** Mathematical Modelling of Metal Forming Processes by Numerical Methods
  - O. Mahrenholtz, N.L. Dung
  - 3

- Plasticity by Boundary Elements
  - I. Potrc, A. Alujevic, P. Les
  - 11

- The Flow Stress of Metals in Warm Forming
  - Z. Marciniak, A. Konieczny
  - 17

- A Plastomechanical Model of the Transfer of Surface Roughness from Tool to Workpiece
  - O. Pawelski, W. Rasp, L. Löffler
  - 23

- **Keynote Paper:** Combined Physical and Numerical Modelling of Metal Forming Processes
  - T. Wanheim, J. Danckert
  - 29

- Application of Boundary Element Method to Cold Forging Die Design
  - Y. Ochiai, R. Wadabayashi
  - 37

- Influence of the Boundary Conditions on Results of the Finite-Element-Simulation
  - R. Kopp, M.L. Cho
  - 43

- Numerical Applications of a Strain-Space Represented Plasticity
  - D. Besdo
  - 51

- Finite Element Analysis of Flattening of Surface Asperities by Rigid Dies in Metal Working Processes
  - A. Makinouchi, H. Ike, M. Murakawa, N. Koga, L.P. Cipulik
  - 59

- Development of Constitutive Equations for Metals at High Temperatures
  - E. Steck
  - 67

- Benchmark Test on a Plastic Deformation Problem
  - Application of numerical methods of analysis to the uniaxial tension of a block or cylindrical bar with both ends fixed
  - T. Jimma, Y. Tomita, S. Shimamura
  - 73

### Tools

- **Keynote Paper:** New Manufacturing Processes of Metal Forming Tools
  - T. Nakagawa
  - 83

- Wear and Life of Blanking Tool Made of Ceramic Materials - Shearing of Amorphous Alloy Foil
  - I. Aoki, K. Suzuki, T. Nakagawa
  - 91

- Stress Relaxation in the Prestressed Dies for Cold Forging
  - C. Kortenski, M. Marinov, G. Pushev
  - 99

- Experiences with PVD Coatings on Cold Forming Tools
  - J. Vogel
  - 103
CAD/CAE

Keynote Paper: CAD/CAM - A State of the Art in Metal Forging Industry
W. Thompson 111

Computer-Aided Engineering in Bulk Metal Forming - Selected Examples
W. Voelkner, J. Leopold 125

CIM Concept and Forming Technology
J. Triouleyre 133

A Blanking Die CAD-System on Microcomputer
X. Ruan, X. Zeng, L. Wang Y. Li 139

A CAD/CAM System for Deep-Drawing Processes
M. Tisza 145

New Processes and CAD-System for Cold Roll Forming of Bending Sheet Parts

Integration of CAD/CAM/CAE in an Aerospace Forging Company
Kh. Hoang-Vu, D.W. Birch 161

Bending

Stationary Sheet Bending Straightening
W. Brekelmans, S.M. Hoogenboom 171

Wrinkling in Out-of-Plane Bending of Elastic-Plastic Circular Plates Subjected to Radial Edge Moments
K. Naruse 177

Spring-back of Clad Sheet Metals in Uniform Stretch Bending under Plane Strain Condition
F. Yoshida, R. Yagi, M. Ohmori 185

Analysis of Springback in Sheet Forming Operation
S.C. Tang 193

On the Strain Distribution in Die Bending of Heavy, Wide, Hot Rolled Steel Plate
M.L. Oliver, K.J. Weinmann 199

Roll Forming for Widely Ranging Thickness Diameter Ratio ERW Pipes
Y. Kuriyama, M. Ataka, Y. Watanabe, T. Nagao 207

Effect of Hydrostatic Stress on Bending Limit of Aluminium Alloys
M. Shinohara 215

Determination of Residual Stresses of the First Order in Deep-Drawn and Bent Workpieces at Different Forming Conditions
E. v. Finckenstein, U. Preckel 223

Investigation of the Behaviour of Coated Thin Sheet Metal During Forming by Bending
E. v. Finckenstein, H. Brox 233

Development of Dieless Bending of Non-Circular Steel Pipes
K. Kobatake, T. Ichise, H. Sekiguchi, K. Osaka 239

Finite Element Simulation of Bending-Restriking Process of Steel Sheets
Y. Nagai, A. Makinouchi 247

Flexible Automated Sheet-Metal Working
H. Klings 265

The Working Limits Caused by Lateral Buckling for In-Plane Bending of Strips
Sh. Sakaki 265

Working Quality and Technological Aspects of Laser Cutting of Sheet Metals
R. Nuss, M. Geiger 273

Blanking/Piercing

The Mechanism of Ductile Fracture during Transverse Shearing
S. Dzidowski 283

Precision Blanking of Electronic Machine Parts
T. Jimma, F. Sekine, K. Sekiya 291
Materials Engineering

Keynote Paper: Constitutive Laws for Strain-, Strainrate- and Temperature Sensitive Metals
E. Steck

High Speed Blanking of an Amorphous Alloy

Deformation-, Temperature- and Time-Induced Phase-Transformation of Two High Alloyed Tool Steels
H. Schrader, P. Funke, H.-D. Kunze

Effects of Ion Implantation on Mechanical Properties of Metals and its Application to Plastic Working
H. Hayashi, M. Iwaki, K. Kawashima, T. Fujihana

The Influence of Texture and Microstructure on Superplasticity of Ti-6Al-4V
B. Baj

Development of Dieless Drawing Process
H. Sekiguchi, K. Kobatake, K. Osakada

An Adverse Effect of Contact Pressure in Cold Pressure Welding
H. Kudo, K. Nakamura, M. Tsubouchi, Y. Matsumoto

Investigations on the Superplastic Behaviour of the Titanium Alloys TiAl 6 V4 an TiAl 5 Fe 2.5 (Rod Material)
U. Zwicker, J. Bremer, W. Lehnen

Testing of Materials:

Keynote Paper: Interaction of Surface Microstructure and Lubricant in Metal Forming Tribology
H. Kudo, A. Azushima

Prediction of Ductile Failure in Forming
P.J. Bolt, J.A.G. Kals, J.H. Dautzenberg

Stresses in Tension-Test Bars after Multi-Pass Drawing of ETPC Copper
E.G. Thomsen

A New Method for Assessing the Deformability of Sheet Material
Comes Back to the Question: Is Uniform Elongation a Valid Term?
H.P. Liebig, R. Beyer

On the Surface Integrity of Mechanically and Thermally Worked Metal Plates
A.G. Mamalis, G.C. Vosnakos, N.M. Vazevanidis

Improved Press-Formability and Strengthening of A 2024 Sheet By Thermomechanical Treatment
T. Mori, N. Kawai

The Effect of Strain Path on the FLD of Coated Steel Sheet
J.Z. Gronostajski, W.J. Ali, M.S. Ghattas

Importance of Deformation-Induced Heating to Sheet Formability
R.H. Wagoner

Effects of the Friction and Deformation Path on Stretch-Formability of Sheet Metal
B. Devedzic, M. Stefanovic

The Effects of Temperature and Speed on the Shearing Characteristics of Sheet Materials
M. Murakawa, K. Nishigaki, N. Koga, K. Ohkawa

The Use of Cold Workability Test Results to Predict FLC as a Function of Stress State
V. Vujovic, M. Planck, D. Vilotic, A.H. Shabaik

The Plastic Response of a Mild Steel under Biaxial Loading Conditions
S.K. Samanta, G. Ardash
Extrusion

Keynote Paper: State of the Art and Development Trends in Cold Forging Technology
R. Geiger

Pressure Distribution over Tool Surfaces in Cold Forging
Sh. Sheljaskov

Combined Extrusion of SiC Whisker/Al-Zn Air-Atomized Powder Composites
H. Asanuma, M. Hirohashi, E. Kawai

Metal Flow in the Rod Extrusion of Rate Sensitive Materials
N. Kanetake, K. Lange

A New Production Method for Automobile Starter Clutch Housings
B. Yonchev

Numerical Simulation of Extrusion of Fin-Tubes and Fin-Bars
M. Kiuchi, S. I-i-jima

Coupled Viscoplastic Flow and Conductive-Convective Heat Transfer during Hot Extrusion
C. Teodosiu

Finite Element Analysis of Non-Symmetric Extrusion Using some Experimental Results
K. Kato, T. Okada, T. Murota, H. Itoh

Flexible Press System for Multiple Metal Forming Processes
Th. Gräbener

Experimental and Theoretical Determination of Container

Trio-Forming of Thin-Wall Cup with Effective Stick Friction
T. Nakamura

Central Bursting in Extrusion of Inhomogeneous Materials
M. Ayada, T. Higashino, K. Mori

Thermal Analysis for Backward Cold Extrusion of Steel Taken
Blue Britteness into Consideration
T. Kato, J. Tozawa, K. Shinagawa

Localization and Dead Metal Zones in Warm Extrusion

Possibilities and Limitations of Cold Extrusion Processes Combined with Radial Extrusion
W. Osen

Improvement of the Extrudability of \( \alpha \)- and \( (\alpha + \beta) \)-Brass by Grain Refinement and Properties in the as Extruded Conditions
J. Breme

Design of Extrusion Punches with Irregular Geometries
K. Lange, T.C. Vu

Influence of Metal Forming Parameters on the Fatigue Behaviour of Extruded Shafts
W. Schwab, B. Hager

Residual Stresses in Axisymmetrically Formed Products
C.S. Hartley

Process-Simulation (Sheet)

Keynote-Paper: Review of Practical Modelling Methods for Sheet Metal Forming
J.L. Duncan, R. Sowerby

A Finite Element Modeling of the Punch Press Forming of Sheet Metal
E. Nakamachi

Simulation of the Forming Process for Irregularly Shaped Autobody Panels
P. Hora, T.C. Vu, P.M. Wollrab, J. Reissner

Analysis and Design of Flange Deformation in Deep Drawing of General Noncircular Cups
D.Y. Yang., W.J. Chung, Y.Y. Cha, Y.J. Kim

Process Modelling of Rotary Tube Cutting-off
P. Bariani, A. Tiziani

Finite Element Simulation of Deep-Draining of Low and High Strength Steel
K. Mattiasson, M. Saran, A. Melander, E. Schedin, C. Gustafsson
Simulation of Deep-Drawing Processes with Special Regard to Circular and Rectangular Cups  
A.W. Behrens  
665

Application the Combined Euler-Lagrange-Method for Mathematical Modelling of Pipe-Angle Forming Process  
G. Krallics, J. Lovas, P. Tamás  
673

Elastic-Plastic FEM Analysis of Bending of Elastically Supported Plate  
N. Hatada, M. Ueda, K. Ueno  
679

Volume II

Stretching, Ironing, Spinning

Deformation and Formability in Bore-Expanding of Metal Sheets from the Aspect of Anisotropic Yield Characteristics  
Y. Kurosaki, M. Matsumoto  
689

Simulation of Sheared Edge Behaviour in Stretch Flanging by a Modified Fukui Test  
Z. Milosevic, F. Moussy  
697

An Improvement in Ironing of Deep Drawn Cans  
K. Miyauchi, T. Aoki  
703

Roller Pass Programming in Conventional Spinning by NC Spinning Machine  
K. Kawai, M. Hayama  
711

A Finite Element Modelling for Deep Drawing of Thin Sheet in Automotive Industry  
E. Massoni, M. Bellet, J.L. Chenot, J.M. Detraux, C. de Baynast  
719

Influence of Plastic Anisotropy on Deformation of Thin-Walled Tubes in Bulge Forming  
S. Fuchizawa  
727

Influence of a Surface Defect on the Stretch Formability of Sheet Metals  
T. Hiroi, H. Nishimura  
733

New Formula for Calculating the Coefficient of Limit in Hole Flanging  
W. Chen, D. Zheng, Sh. Yao  
741

A Contribution to Deep Drawing with Simultaneous Ironing of very Thin Sheet Material  
H. Wolf, L. Rütz, G. Effenberger  
745

Rolling

Mashy-State Rolling of Composite Sheets  
M. Kiuchi, S. Sugiyama  
753

The Upper Bound Solution for Three-Dimensional Deformation in Roll Forging of Blank  
Ch. Zhang, Y. Tai, G. Ren  
759

New Approach for Predicting Ring Rolling Procedure  
P. Boucly, J. Oudin, Y. Ravalard  
765

Rheological Interpretation to Prevent Faults Observed in Products on Ring Rolling Process  
Y. Maekawa, T. Hirai, T. Katayama, J.B. Hawkyard  
773

Study on Bending-Rolling Combined Forming Technique  
Y. He, W. Chen, F. Zhang  
781

Solid Phase Roll Cladding of Bimetallic Strip by Cross Shear Cold Rolling  
Q. Zhu  
789

Mechanism of Polygonning Formation of Tube Bore in Stretch Reducing  
Y. Sodani, T. Hiraoka, Y. Mihara  
795

New Control System for Ringrolling  
R. Kopp, U. Koppers, H. Wiegle  
803

CAD Application in Forge Rolling  
K. Kuzmann, M. Pirtovsek  
809

Simulation of Ring Rolling Process  
E. Dooge, M. Aboutour  
817
Drawing (bar, wires, tubes)

Keynote Paper: The influence of Strain Path on Wire Properties
P. Huml 827

Finite Element Analysis of the Shear Strain in the Axisymmetric Drawing
M. Pietrzyk, J. Luksysa, L. Sadok 835

Simulation of Drawing-Processes by the Finite Element Method
J. Gerhardt, A.E. Tekkaya 841

Wire Drawing at Elevated Temperatures: Experimental and Theoretical Comparison
N. H. Loh, D.H. Sansome 849

Cup-Shaped Defect in Copper Wires Drawn from Rods of Continuous Casting and Rolling
K. Yoshiida, H. Tanaka 857

Experimental Mechanics of Shaped Bar Drawing
R.N. Wright, P.B. Martine, Y. Yi 863

Tribology

Keynote Paper: Friction Laws in Metal Forming Tribology
J. A. Schey 873

A Model for the Characterization of Friction Resistance to Sliding as a Function of Load,
Speed and Viscosity and Geometry
B. Avitzur 883

The Push-Drawn-Test, a New Method for Determination of Friction Coefficient
on Condition of Plastic Deformation
O. Pawelski, W. Rasp, U. Mohr 889

Adhesion Strength of Phosphate Coatings in Cold Forming
H. Y. Oei 893

Effect of Tool Workpiece Contact Length on Friction Coefficient in Metal Forming
S. Shima, N. Yamamoto 901

Flattening of Rough Expanding of Plastically Deformed Bulk
Loaded with a Flat and Hard Plate
L.F. Clupik, H. Ike, A. Makinouchi, J. Mstowski 909

A Friction and Lubrication Test for Cold Forging
N. Bay, B.E. Christopherson 917

Lubrication in Isothermal Forging with Ceramic Dies
K. Osakada, M. Shiraishi 925

Press Joining of Especially Coated Steel and Aluminium Sheets
H.P. Liebig, R. Beyer 933

Powder Metal Forming

Keynote Paper: Generation of Metal Products with New Properties by Combined Powder Metallurgy and Deformation Processes
W.J. Huppmann, V. Arnhold 943

Modelling of Aluminium Alloy Powder Hot Forging Process in View of Computer Aided Design (CAD) of Preform
C. Levaillant, J.L. Querbes, C. Laugée, P. Amouroux 953

Application of the Finite Element Method to P/M Forming Processes
S.I. Oh, W.T. Wu, J.J. Park 961

New Yield Function for Forming Processes of Porous Materials
J. Duszycky 969

A Modified Slip-Line Field Theory for Sintered Porous Metals
Sh. El Wakil 977
Forging

Keynote Paper: State of the Art and Trends in Hot Forging
H. Meyer-Nolkenper 987

Simulation and Limit State in Metal Forming
G. Zsida, L. Cser, Z. Darvas 999

T. Wada, T. Nanba 1006

A Criterion for Ductile Fracture in Cold Forging
N.L. Dung, O. Mahrenholtz 1013

Keynote Paper: Process Simulation of Hot Die Forging Processes
T. Altan 1021

An Analysis of Void Crushing during Flat Die Free Forging
M. Tanaka, S. Ono, M. Tsuneno, T. Iwadate 1035

Computer-Aided Roll Forging
B. Kattanoglou, A. Nassirharand 1043

Thermo-Mechanical Finite Element Calculation of Three-Dimensional
Hot Forging with Remeshing
J.P. Cescutti, N. Soyris, G. Surdon, J.L. Chenot 1061

Analysis of the Closing and Consolidation of Internal Cavities in Heavy Rotor Forgings
by Finite Element Method
J. Sun, H. Guo 1059

Finite Element Modelling of a Radial Forging Process
T. Rodic, B. Stok, F. Gologranc, D. Owen 1065

Improved Properties of Forged Superalloys - Results of a Better Modelling and
Controlling of the Forging Process
G. Schröder, H. Rydstad, G.H. Gassinger 1073

Metal Flow and Tool Stress in Cold Forging of Gear Components
F. Dohmann, O. Traudt 1081

Investigation into Forming Processes of Various Spur Gears
K. Kondo, K. Ohgä, K. Hori 1089

Simulation of Plane Strain H - Shape Forging Using Non-FEM Method
M. Abebe 1097

Finite Element Simulation of Metal Flow around Round Corner of Tool
K. Mori, K. Osaka, T. Ieda, M. Fukuda 1105

Material Influences on Plastic Flow Localization and Instability in Metal Processing
W.R. Steinhurst, B.F. von Turkovich 1111

NC-Radial-Forging - Present State of Further Development
A. Wöhr, K. Lange 1119

Problems of Introducing FMC in Forging
Y.A. Bocharov 1133

Fundamentals: Sheet Forming

Keynote Paper: State of the Art of Sheet Metal Forming and Future Trends
W. Panknin 1143

Mechanics of Drawing with Rubber Pads
M. Holzner, V. Mannl 1151

Deep-Drawing of Shells with Bi-Level Bottoms
T. Jimma, T. Kuwabara 1159

Deformation Mechanism in a Dual Phase Steel
F. Moussy 1165

Initiation of Buckling in Anisotropic Metal Sheet
A.M. Szaczynski, P.F. Thomson 1171

State of Development in the Forming of Thick Sheet Metal
O. Schmoeckel, E. Böhm 1179

Process Simulation and Adaptive Control in Sheet Metal Forming
E. v. Finckenstein, M. Kleiner 1187
Production of Small Batch Quantities Employing Flexible Production Systems in Metal Forming
R. Kellenbenz, H. Hoffmann

Tooling Concepts for Large Transfer Presses
A Quantum Leap in Production Technology of Large Automotive Body Panels
M. Bräutigam

Process-Simulation (Bulk)

Keynote-Paper: Process Design in Metal Forming by the Finite Element Method
S. Kobayashi

Physical Simulation for Metal Forming with Strain Rate Sensitive
Model Material
A. Azushima, H. Kudo

Multi-Level Simulation of Metal Forming Processes
R. Kopp, M.L. Cho, M. de Souza

Modelling of Free Large Processes by Photo-Electric Scanning Moire Method
C. Qao, S. Ye, B. Xie, Y. Zhong

Materials Modelling and Intrinsic Workability for Simulation of Bulk Deformation
J.S. Gunasekera, H.L. Gogel, J.C. Malas, S.M. Doraiselvul, J.M. Alexander

Drawing (Sheet)

Keynote Paper: Interactions between Cold Rolled Sheet Steel and Forming Process
Ch. Straßburger, K. Blümel, W. Prange,

Simulation of the Buckling Phenomenon in Sheet Metal Forming by a Test on Flat Circular Specimens
Z. Milosevic, C. Botte, F. Moussy

FEM Simulation of Surface Roughening and its Effects on Forming Limit in Stretching of Aluminium Sheets
K. Yamaguchi, N. Takakura, M. Fukuda

Effect of Forming Temperature on the Deep Drawability of Aluminium Alloy Sheets
M. Sugamata, J. Kane, M. Suzuki, H. Usagawa

Temperature Dependency of Mechanical Properties of Steel Sheets and its Application to Deep Drawing in Warm Condition
T. Ohwue, H. Takechi, Y. Furuno

Earing and Delayed Cracking of Deep-Drawn Cup of Austenitic Stainless Steel Sheets
H. Sumitomo

An Improvement in Deep Drawability of Steel/Plastic Laminate Sheets by Control of Blank Holding Force
K. Manabe, H. Hamano, H. Nishimura

Blank-Holder Pressure and Blank-Holder Layout in Deep Drawing of Thin Sheet Metal
E. Doege, N. Sommer

Extrusion Augmented Drawing - A New Technique for Forming Protrusion
C.B. Cowley, J. Dransfield

Improvement of Tooth Profile Accuracy in Finish Gear Rolling of Helical Gears
T. Ozaki

A New Cladding Process Combining Bulge Forming and Squeeze Casting
T. Dendo, T. Shirato, S. Kojima

Investigations of the “Grob” Cold Shape-Rolling Process
N. Kurz

Superplasticity and Grain Boundary Relaxation in High Carbon Tool Steel
Ch. Kortensky, N. Mitev, I. Spirov, N. Dyulgerov

Theoretical Prediction on Non-Axisymmetric Buckling in Tube Nosing
J. Endo, K. Kato, T. Murota, N. Hatada