

3<sup>rd</sup> International Conference

**HOT SHEET METAL FORMING  
of HIGH-PERFORMANCE STEEL  
CHS<sup>2</sup>**

June 13-17, 2011, Kassel, Germany

**Proceedings**

3<sup>rd</sup> International Conference

**HOT SHEET METAL FORMING  
of HIGH-PERFORMANCE STEEL  
CHS<sup>2</sup>**

June 13-17, 2011, Kassel, Germany  
Proceedings

Edited by  
Prof. Mats Oldenburg, Luleå University of Technology, Sweden  
Prof. Kurt Steinhoff, University of Kassel, Germany  
Prof. Braham Prakash, Luleå University of Technology, Sweden

All rights reserved.  
No part of this publication may be reproduced or transmitted  
by any means, electronic, mechanical, photocopying or otherwise  
without the prior permission of the publisher.

© 2011  
Verlag Wissenschaftliche Scripten  
Kaiserstrasse 32, 08209 Auerbach, Germany  
[info@verlag-wiss-scripten.de](mailto:info@verlag-wiss-scripten.de)  
[www.verlag-wiss-scripten.de](http://www.verlag-wiss-scripten.de)

ISBN: 978-3-942267-17-5

# Table of Contents

## Tailored Properties I (A1)

<b>Tailored Properties – A Pivotal Question for Hot Forming .....</b>	<b>13</b>
---	-----------

*Janko Banik, Franz-Josef Lenze, Sascha Sikora and Robert Laurenz*

<b>Tailored Tempering – Heat Transfer and Resulting Properties in Dependency of Tool Temperatures .....</b>	<b>21</b>
---	-----------

*Thomas Svec and Marion Merklein*

<b>Hot Forming of a Lab-Scale B-Pillar with Tailored Properties – Experiment and Modeling .....</b>	<b>31</b>
---	-----------

*Ryan George, Alexander Bardelcik and Michael J Worswick*

## Materials Testing & Failure Prediction (B1)

<b>Failure Model Evaluation for Varying Microstructure Based on Material Hardness .....</b>	<b>41</b>
---	-----------

*Rickard Ostlund, Mats Oldenburg, Hans-Åke Haggblad and Daniel Berglund*

<b>Local Characterization of Mechanical Properties of Hot Formed Parts .....</b>	<b>49</b>
--	-----------

*Manuel Maikranz-Valentin, Jörg Clobes, Monika Schulz,  
Steffen Kulp, Michael Alsmann and Kurt Steinhoff*

<b>Numerical Prediction of Failure in High Temperature Formblowing and Hardening .....</b>	<b>57</b>
--	-----------

*Göran Lindkvist, Hans-Åke Haggblad and Mats Oldenburg*

## Tools & Dies (A2)

<b>Integrated and Competitive Tooling Solutions for the Production of Tailored Components and Cutting of UHSS .....</b>	<b>67</b>
---	-----------

*Anna Ingebrand, Isaac Valls Anglès and Till Laumann*

<b>The Effect of Die Constructions on the Formability of Hot Stamped Automobile Part .....</b>	<b>75</b>
--	-----------

*Se Yun Ha, Pan Ki Seo, Byung Min Kim and Chung Gil Kang*

<b>Effect of the Cutting Process in the Mechanical and Fatigue Properties of Press Hardened 22MnB5 Steel .....</b>	<b>85</b>
--	-----------

*Ingrid Picas, Ricardo Muñoz, Antoni Lara,  
Ricardo Hernández and Daniel Casellas*

<b>Investigations into the Failure Mechanisms of Form Fixture Hardening Tools .....</b>	<b>93</b>
<i>Leonardo Pelcastre, Jens Hardell, Natalia Herrera and Braham Prakash</i>	

## **Flow Behaviour & Formability (B2)**

<b>Draw-Bending Formability of Steel Sheets in Hot Stamping Process .....</b>	<b>107</b>
<i>Kazuhisa Kusumi, Naruhiko Nomura, Shuji Yamamoto and Masayoshi Suehiro</i>	

<b>Investigations on the Flow Behavior of Boron-Manganese Steels at Elevated Strain Rates .....</b>	<b>115</b>
<i>Thomas Stöhr and Marion Merklein</i>	

<b>Stretch-Flange Formability of Boron Steel in Hot Stamping .....</b>	<b>123</b>
<i>Masahiro Nakata, Yasuhiro Ito, Kazuo Uematsu, Kazuo Hikita, Toshiya Suzuki and Nobusato Kojima</i>	

<b>Study of Influence of Forming Velocity and Friction Coefficient on Formability of Hot Stamping by FEM Simulation .....</b>	<b>133</b>
<i>Naruhiko Nomur, Kazuhisa Kusum and Masayoshi Suehiro</i>	

## **Coatings & Corrosion I (A3)**

<b>Zinc-Coated Boron Steel, ZnX®: Direct Hot Forming for Automotive Applications .....</b>	<b>145</b>
<i>Marc J. van Genderen, Wico C. Verloop, Jenny Loiseaux and Guido C. Hensen</i>	

<b>Corrosion Resistance of Zinc Based and Aluminized Coatings on Press-Hardened Steels for Automotive .....</b>	<b>153</b>
<i>Christian Allély, Jaques Petitjean and Thomas Vietoris</i>	

<b>A Ductile Aluminide Coating for Hot Stamping .....</b>	<b>161</b>
<i>Dong Wei Fan and Bruno C. De Cooman</i>	

## **Industrial Applications I (B3)**

<b>Developments in the Field of Schwartz Heat Treatment Furnaces for Press Hardening Industry .....</b>	<b>171</b>
<i>Harald Lehmann</i>	

<b>Compact Line Conception for Hot Forming Lines .....</b>	<b>181</b>
<i>Eduardo Gamboa, Xabier Agirretxe, José Miguel Martin and Koldo Gorostiza</i>	

<b>Continuous Improvement of Hot Forming Technology .....</b>	<b>189</b>
<i>Ralf Hund</i>	

## **Tailored Properties II (A4)**

<b>Tool Thermal Cycle Design for Manufacturing of Components with Tailored Material Properties .....</b>	<b>203</b>
<i>Mats Oldenburg and Göran Lindkvist</i>	

<b>Numerical Optimization of Temporally and Spatially Varying Temperature Distributions for the Production of Functionally Graded Materials with Tailored Microstructural Properties .....</b>	<b>211</b>
<i>Jörg Clobes, Dennis Fuß, Michael Alsmann, Hans-Josef Watermeier, Hans-Helmut Becker and Kurt Steinhoff</i>	

<b>An Impact Model of a Hot Stamped Lab-Scale B-Pillar with Tailored Properties .....</b>	<b>221</b>
<i>Alexander Bardelcik, Kamyar Ghavam, Ryan George and Michael J Worswick</i>	

<b>Enhancement of Process Stability and Part Quality for the Press Hardening of Sheet Metal .....</b>	<b>229</b>
<i>Reimund Neugebauer, Angela Göschel, Frank Schieck, Anja Rautenstrauch, André Mosel and Hangfeng Cai</i>	

## **Industrial Applications II (B4)**

<b>Process Optimization of Laser Cutting and in the Heating Process .....</b>	<b>239</b>
<i>Michael Fritz</i>	

<b>HotPHASE – Press Hardening Automotive Solutions by EBNER.....</b>	<b>247</b>
<i>Fritz Josef Ebner</i>	

<b>Past and Future for Taylor-Made Hot Stamping Lines .....</b>	<b>255</b>
<i>Jose Mari Berasategi, César Garbalena, Gorka Irazu and Beatriz González</i>	

<b>Press Hardening – Process Design .....</b>	<b>263</b>
<i>Kent Eriksson</i>	

## **Case Studies I (A5)**

<b>Market Development and Technological Perspectives in Press Hardening of UHSS .....</b>	<b>271</b>
<i>Matthias Schupfer and Kurt Steinhoff</i>	

<b>Extensive Use of Hot-Formed Steel in Car Body Structures .....</b>	<b>283</b>
<i>Richard Johansson, Mikael Fermér, Johan Jergéus and Johnny K. Larsson</i>	

## Parts & Processes I (B5)

<b>Experimental Estimation of Heat Transfer Coefficients in the Hot Stamping Process of Usibor®1500P .....</b>	<b>293</b>
--	------------

*Christine Dessain, Joël Wilsius, Gilles Brun,  
Bakri Abdulhay and Brahim Bourouga*

<b>Process Development for Manufacture of an Automotive Structural Part by Means of Applasting Technology .....</b>	<b>303</b>
---	------------

*Leire Vadillo, Daisuke Yamamoto, Izuru Hori, Jose Ignacio Zarazua,  
Iñaki Pérez, Sonia Varela, Rodrigo Berlanga and Juan San José*

## Modeling & Simulation (A6)

<b>Progress on the Finite Element Simulation of the Hot Stamping Process .....</b>	<b>315</b>
--	------------

*Ambi Naganathan, Parichapol Sartkulvanich,  
Deepak Ravindran, Norbert Pierschel and Taylan Altan*

<b>About the Simulation of Microstructure Evolution in the Hot Sheet Stamping Process and the Correlation of Resulting Mechanical Properties and Crash-Performance .....</b>	<b>323</b>
--	------------

*Stephane Graff, Thomas Gerber,  
Franz-Josef Lenze and Sascha Sikora*

<b>Research on Tailored Microstructure Material in Hot Forming and its Application .....</b>	<b>331</b>
--	------------

*Ning Ma, Ping Hu and Zonghua Zhang*

<b>Formability Simulation or Cooling Simulation – or Both? .....</b>	<b>341</b>
--	------------

*Martin Skrikerud, Ole Köser and Mustafa Megahead*

## Friction & Wear & Lubrication (B6)

<b>Application of Lubricant in Hot Stamping of Aluminum Coated High Strength Steel .....</b>	<b>353</b>
--	------------

*Akira Azushima, Akira Yanagida and Kosuke Uda*

<b>Wear Behavior of Uncoated and Coated Tools With Respect to Different Loading Conditions .....</b>	<b>361</b>
--	------------

*Michael Wieland and Marion Merklein*

<b>Effect of Surface Roughness of Die and Scale Thickness on Coefficient of Friction of Boron Alloyed Quenchable Steel in Hot Stamping .....</b>	<b>369</b>
--	------------

*Akira Yanagida, Yudai Tanaka and Akira Azushima*

<b>Wear Mechanism Identification on Hot Stamping Tools .....</b>	<b>377</b>
--	------------

*Jaume Pujante, Montserrat Vilaseca, Katarina Eriksson,  
Jörg Clobes, Michael Alsmann and Daniel Casellas*

## Case Studies II (A7)

<b>Development of Structural Components in Indian Automotive Industry Through Hot Forming .....</b>	<b>387</b>
<i>Dhananjay Kumar</i>	
<b>Humans Love Progress but Hate Change – From Vision to Reality .....</b>	<b>397</b>
<i>Stefan Scheurer</i>	

## Parts & Processes II (B7)

<b>Novel Approach of Thermo-Mechanical Forming Technology for Development of Multi-Laminated Composite Parts .....</b>	<b>407</b>
<i>Natalie Barbakadze, Sven Wagner, Ursula Weidig, Agim Ademaj and Kurt Steinhoff</i>	
<b>New Applications of Press Hardening Technology: Skin Outer Parts .....</b>	<b>415</b>
<i>Ignacio Garcia, Miren Redondo, Jose Ignacio Zarauzua and Borja Fernandez</i>	

## Tailored Properties III (A8)

<b>Experimental and Numerical Investigation of Various Hot Stamped B-Pillar Concepts Based on Usibor®1500P .....</b>	<b>427</b>
<i>Joël Wilsius, Bertrand Tavernier and Damien Abou-Khalil</i>	
<b>Tailor Strategies in Press Hardening .....</b>	<b>437</b>
<i>Borja Fernández, Jon Zarate, Ignacio García and Sonia Varela</i>	
<b>A Thermo-Mechanical-Metallurgical FE Approach for Simulation of Tailored Tempering .....</b>	<b>447</b>
<i>Serkan Ertürk, Matthias Sester, Mike Selig, Peter Feuser and Karl Roll</i>	

## Heating & Cooling (B8)

<b>Influence of Different Heating Technologies on the Coating Properties of Hot-Dip Aluminized 22MnB5 .....</b>	<b>457</b>
<i>Philipp Siebert, Michael Alsmann and Hans-Josef Watermeier</i>	
<b>Effect of Rapid Heating on Evolution of Microstructures and Coating Layers in Hot Stamping Processes .....</b>	<b>465</b>
<i>Takahide Senuma and Yoshito Takemoto</i>	

<b>Fluidized Bed Heating of Blanks for the Hot Forming Process .....</b>	<b>473</b>
<i>Thorsten Marten, Thomas Tröster, Stefan Adelbert and Abdel Kadim</i>	

<b>Induction Heat Treatment for Press Hardening Process .....</b>	<b>481</b>
<i>Holger Schülbe, Marcel Jestremski and Bernard Nacke</i>	

## **Coatings & Corrosion II (A9)**

<b>Trends and Developments in the Usability and Production of Press-Hardened Components with Cathodic Corrosion Protection .....</b>	<b>491</b>
<i>Thomas Kurz, Martin Rosner, Thomas Manzenreiter, Dieter Hartmann, Andreas Sommer, Reiner Kelsch and Agim Ademaj</i>	

<b>Effect of Heating Condition and Hot Forming on Corrosion Resistance of Hot Stamped Aluminized Steels .....</b>	<b>499</b>
<i>Jun Maki, Masao Kurosaki, Kazuhisa Kusumi and Masayuki Abe</i>	

## **Microstructure & Phase Transformation (B9)**

<b>Metallurgical Behaviour of Uncoated and Galvannealed Boron Steels in Hot Stamping Process .....</b>	<b>511</b>
<i>Nobusato Kojima, Toshinobu Nishibata, Kazuhito Imai, Koji Akioka, Kazuo Hikita, Koutarou Hayashi and Hirohisa Kikuchi</i>	

<b>Bainitic Transformation under Compressive Stress in Low Alloy 51 Cr V4 Steel .....</b>	<b>519</b>
<i>Martin Joachim Holzweißig, Hans-Gerd Lambers and Hans Jürgen Maier</i>	