TABLE OF CONTENTS

Preface.......................................................................................................................................... ix

Characterization and Application

High Strength Discontinuously Reinforced Aluminum for Rocket Applications ............................................................ 3
  A.B. Pandey, S.R. Shah and M. Shadoan

Low Cost Cast Aluminum Metal Matrix Composites Have Arrived ................................................................. 13
  D. Herling and W. Hunt, Jr.

A Simplified Test for Blanching Susceptibility of Cu Alloys ................................................................................. 25
  L.U.J.T. Ogbuji, D.L. Humphrey and J.A. Setlock

Creep of Ni-Al and Ni-Cr-Al Superalloy Foams ................................................................................................. 35
  H. Choe and D.C. Dunand

Effects of Processing on High Strain Rate Response of Boron Carbide Particulate Reinforced 6092 Aluminum ......................................................... 43
  H. Zhang, K.T. Ramesh and E.S.C. Chin

Fatigue, Fracture, Creep & Wear

Processing and Mechanical Behavior of UltraFine SiC Particular-Reinforced Aluminum Composites .... 51
  C.A. Smith, M.R. van den Bergh and J.-M. Yang

Cyclic Behavior of Transverse Loaded Titanium Matrix Composites ............................................................... 61
  J.M. Hausmann, S. Emura and C. Leyens

Microstructure and Recrystallization Behavior of Boron Carbide Reinforced Nanocrystalline Aluminum Composites ......................................................... 71
  J. He, J. Ye, D. Witkin and J.M. Schoenung

Fatigue Damage of Ti-6242/SCS-6 Metal Matrix Composite ........................................................................ 81
  D. Bettge, B. Gänther, W. Wedell, P.D. Portella,
  J. Hemptenmacher and P.W.M. Peters

Tribological Properties of Magnesium Composite with In-Situ Formed Mg$_2$Si Dispersoids .............................................................. 91
  K. Kondoh, H. Oginuma and T. Aizawa
Processing of MMC’s

Producing AlN-Al Alloy Composites by In-Situ Reacting Bubbling Ammonia Gas with Molten Aluminum .................................................................105

Q. Zheng and R.G. Reddy

Effect of Processing on the Microstructure and Properties of Ti-6Al-4V-xB Alloys ..........................................................115

R.B. Bhat, S. Tamirisa, D.J. McEldowney
and D.B. Miracle

Effects of Oxygen Impurities on In-Situ Formation of AlN-Al Composites From Nitrogen Bubbling Gas .........................................................125

Q. Zheng and R.G. Reddy

Solidification Structures in Aluminum Composites by Heat Extraction Through Reinforcing Carbon Fibers ..................................................135

H.G. Seong, J.K. Kim, P.K. Rohatgi, E.K. Lee
and R. Amano

Low Temperature Synthesis of Boron Carbide Reinforced Nanocrystalline Aluminum Composites ..........................................................147

J. He, J. Ye and J.M. Schoenung

Formability of a High Performance Dispersion Strengthened Cu-Cr-Nb Composite ..................................................................................157

A. Awadallah, G.M. Michal, D.L. Ellis
and J.J. Lewandowski

Ceramic Powder Encapsulated by Nanocrystalline Metallic Coating ..........................................................167

J. He, Y. Zhou, D. Baker, B. Harrigan
and E.J. Lavernia

Effects of Rolling Conditions on the Properties of Al-SiC Composites Fabricated by Plasma Spray Forming ....................................................173

K. Euh and S.B. Kang

Strengthening Mechanisms

Strength Modeling of a Titanium Alloy Modified with Boron and Boron+Carbon .................................................................................185

S. Tamirisakandala, R.B. Bhat, D.J. McEldowney
and D.B. Miracle

Precipitation Strengthening in Al(Sc,Ti) Alloys ..................................................195

M.E. van Dalen, D.C. Dunand and D.N. Seidman
Influences of Micro and Macrostructure on Tensile and Fatigue Properties of Permanent Mold Cast A359/SiC Composites .................................................................203
   P.K. Rohatgi, J.K. Kim, H.G. Seong and R. Thakker

Mechanical Properties of a Heat-Treatable Al-Sc Alloy Reinforced with
Al$_2$O$_3$ Dispersoids ..................................................................................................................215
   R.A. Karnesky, L. Meng, D.N. Seidman
   and D.C. Dunand

Diffraction Measurements of Load Transfer in Interpenetrating-Phase
Al$_2$O$_3$/Al Composites ............................................................................................................225
   M.L. Young, J.D. Almer, U. Lienert, D.R. Haeffner,
   R. Rao, J.A. Lewis and D.C. Dunand

Author Index ................................................................................................................................235
<table>
<thead>
<tr>
<th>Section</th>
<th>Author(s)</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preface</td>
<td></td>
<td>ix</td>
</tr>
<tr>
<td>Acknowledgements/Organizing Committee</td>
<td></td>
<td>xi</td>
</tr>
<tr>
<td>Peer Review Committee</td>
<td></td>
<td>xiii</td>
</tr>
<tr>
<td><strong>Thermodynamics and Kinetics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The Bay Phenomenon in Steels with Reasonably Strong Carbide Formers</td>
<td>M. Hillert and L. Höglund</td>
<td>3</td>
</tr>
<tr>
<td>The Role of Carbon on the Kinetics of Bainite Transformation in Steels</td>
<td>D. Quidort and Y. Bréchet</td>
<td>15</td>
</tr>
<tr>
<td>The Influence of Alloy Element Partitioning on the Shapes of TTT Start</td>
<td>R.E. Hackenberg and G.J. Shiflet</td>
<td>27</td>
</tr>
<tr>
<td>Effects of High Magnetic Field on Phase Transformation Behavior and</td>
<td>H. Ohtsuka, X. Hao and H. Wada</td>
<td>43</td>
</tr>
<tr>
<td>Structure in Fe-Based Alloys</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The Diffusional Formation of Allotriomorphic Ferrite from Austenite in</td>
<td>C.R. Hutchinson, A. Fuchsmann, H. Zurob</td>
<td>49</td>
</tr>
<tr>
<td>Fe-C-X Systems. The Simplest Case: Fe-C-Ni</td>
<td>C.R. Hutchinson, A. Fuchsmann, H. Zurob</td>
<td></td>
</tr>
<tr>
<td>and Y. Bréchet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interfacial Conditions at the Moving Interface During Growth of Ferrite</td>
<td>G. Inden and C.R. Hutchinson</td>
<td>65</td>
</tr>
<tr>
<td>from Austenite in Fe-C-(X) Alloys</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Competition Between Allotriomorphic and Idiomorphic Ferrite Kinetics</td>
<td>C. Capdevila, F.G. Caballero</td>
<td>81</td>
</tr>
<tr>
<td>Influencing of Alloying Element Accumulation at α/γ Boundaries on the</td>
<td>M. Enomoto</td>
<td>97</td>
</tr>
<tr>
<td>Growth of Proeutectoid Ferrite in Fe-C-Mn Alloys</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer Prediction of Para-Equilibrium Transformations</td>
<td>B. Sundman</td>
<td>113</td>
</tr>
<tr>
<td>Title</td>
<td>Authors</td>
<td></td>
</tr>
<tr>
<td>-------------------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>A Study of the Transition Kinetics from Para-Equilibrium to Ortho-Equilibrium</td>
<td>J.M. Vitek, S.S. Babu and E. Kozeschnik</td>
<td></td>
</tr>
<tr>
<td>Non-Equilibrium Reaction Paths in Ferrous Austenite Decomposition</td>
<td>R.E. Hackenberg and G.J. Shiflet</td>
<td></td>
</tr>
<tr>
<td>Deviation from Local-Equilibrium During Austenite to Ferrite Transformation</td>
<td>J. Ågren</td>
<td></td>
</tr>
<tr>
<td>Modeling and Characterization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Challenges in Modeling the Overall Austenite Decomposition Kinetics</td>
<td>M. Militzer</td>
<td></td>
</tr>
<tr>
<td>Influence of Thermomechanical Treatment on the Austenite-Pearlite Transformation in a High Carbon Nb-Microalloyed Steel</td>
<td>E. Cotrina, B. López and J.M. Rodriguez-Ibabe</td>
<td></td>
</tr>
<tr>
<td>Modelling the Effects of Microalloying on the Hardenability of High Strength Steels</td>
<td>T. Siwecki and B. Rodell</td>
<td></td>
</tr>
<tr>
<td>In-Situ Characterization of Austenite to Martensite Decomposition in 9Cr-1Mo-V Steel Welds</td>
<td>M.L. Santella, S.S. Babu, R.W. Swindeman and E.D. Specht</td>
<td></td>
</tr>
<tr>
<td>Prediction of Phase Transformation Kinetics and Microstructures in Low-Carbon High Strength Steels</td>
<td>T. Iung, M. Kandel, S. Lacroix, A. Perlade and D. Quidort</td>
<td></td>
</tr>
<tr>
<td>Austenite Decomposition: Modelling and Measuring at the Level of Individual Grains</td>
<td>S. van der Zwaag, J. Sietsma, E. Offerman and N. van Dijk</td>
<td></td>
</tr>
</tbody>
</table>
Simulation of Proeutectoid Ferrite Precipitation During Technical Heat Treatment

G. Pariser, P. Shaffnit, I. Steinbach and W. Bleck

Microstructure Characterization of the Austenite Decomposition of HSLA Steel Strip

J. Wu, P.J. Wray, M. Hua, C.I. Garcia and A.J. DeArdo

On the Role of Kinematics in Constructing Predictive Models of Austenite Decomposition

M.T. Lusk, W. Wang, X. Sun and Y.-K. Lee

Two Problems in Ledgewise Growth of Ferrite Requiring Further Advanced Experimental Techniques for Their Solution

W.T. Reynolds, Jr., H.I. Aaronson and H. Goldstein

Characterization and Prediction of Austenite Formation and Decomposition in Steel Welds

S.S. Babu, J.M. Vitek, S.A. David, T. Palmer and J.W. Elmer

Analysis of the $\gamma \rightarrow \alpha$ Transformation in a C-Mn Steel by Dilatometry, Laser Scanning Confocal Microscopy and Phase Field Modelling

M.G. Mecozzi, J. Sietsma, S. van der Zwaag, M. Apel, P. Shaffnit and I. Steinbach

Influence of Deformation on Austenite to Ferrite Transformation in Low Carbon Steels: Experimental Approach and Modelling

S. Lacroix, Y. Bréchet, M. Véron, D. Quidort, M. Kandel and T. Iung


N.J. McDonald and S. Sridhar

Austenite and Cementite

The Divorced Eutectoid Transformation and Spheroidization of Steels

G.M. Michal and M.D. Novak

The Proeutectoid Cementite Transformation

G. Spanos and M.V. Kral

The Interfacial Structure of Widmanstätten Cementite Laths

R.W. Fonda, M.V. Kral and W.T. Reynolds, Jr.
Precipitate Coarsening and Grain Growth in Steels ................................................................. 437
K.C. Russell

Contribution to the Study of Austenite Formation in Steels ...................................................... 457
F.G. Caballero, C. Capdevila, D. San Martín
and C. Garcia De Andrés

Modeling the Formation of Austenite from Ferrite-Carbide Aggregates ............................... 475
M. Hunkel, H. Surm, Th. Lübben, O. Kessler,
F. Hoffman and P. Mayr

Fundamentals of Multiphase Steels

Transformation Toughening in Dispersed-Phase Systems ......................................................... 493
G.B. Olson and C.J. Kuehmann

Quenching and Partitioning: A Fundamentally New Process to Create
High Strength Trip Sheet Microstructures ................................................................................... 505
J.G. Speer, A.M. Streicher, D.K. Matlock, F. Rizzo
and G. Krauss

On the Austenite Retention in Low Alloys Steels ................................................................. 523
S. Godet, C. Georges and P.J. Jacques

Quasi-Adiabatic Effects During the High Strain Rate Deformation of
Dispersed-Phase Systems with Strain-Induced Martensitic Transformation ........................... 537
B.C. De Cooman, L. Samek, J. Mahieu,
J. Van Slycken, P. Verleysen, J. Degrieck, L. Lin,
L. Wang, X.C. Wei and S. Peng

Phase Transformation Behavior During Continuous Cooling and
Isothermal Holding of Aluminum and Silicon Bearing Trip Steels ........................................ 549
N. Fonstein, N. Pottore, S.H. Lalam
and D. Bhattacharya

Effect of Annealing Temperature on Austenite Decomposition in a
Si-Alloyed Trip Steel .................................................................................................................. 563
M.F. Gallagher, J.G. Speer and D.K. Matlock

The Influence of Nb on the Phase Transformations and Mechanical
Properties in Al- and Si-Alloyed Trip-Steels ............................................................................ 577
S. Traint, A. Pichler, K. Spiradek-Hahn, K. Hulka
and E. Werner

Author Index .............................................................................................................................. 595
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreword</td>
<td>xi</td>
</tr>
<tr>
<td>Session Chairpersons</td>
<td>xiii</td>
</tr>
<tr>
<td>PLENARY, THERMODYNAMICS AND BIO-PROCESSING</td>
<td></td>
</tr>
<tr>
<td>New Opportunities in Optimization and Control of Metals Processing</td>
<td>3</td>
</tr>
<tr>
<td>(Plenary)</td>
<td></td>
</tr>
<tr>
<td>H. Shang, J.B. Wiskel, J.F. Forbes and H. Henein</td>
<td></td>
</tr>
<tr>
<td>Interactions of Molten Fe-Cr Alloy with Refractories (Plenary)</td>
<td>15</td>
</tr>
<tr>
<td>Y. Mizukami, T. Itoh, M. Kimoto, T. Miki, T. Nagasaka and M. Hino</td>
<td></td>
</tr>
<tr>
<td>On-line Detection of Quality Problems in Continuous Casting of Steel</td>
<td>29</td>
</tr>
<tr>
<td>(Plenary)</td>
<td></td>
</tr>
<tr>
<td>B.G. Thomas</td>
<td></td>
</tr>
<tr>
<td>Process Control, Optimization and Automation through Modeling and</td>
<td>47</td>
</tr>
<tr>
<td>Simulation (Plenary) (Abstract Only)</td>
<td></td>
</tr>
<tr>
<td>F. Kongoli, I. McBow and S. Llubani</td>
<td></td>
</tr>
<tr>
<td>Effects of Ca Addition on the Thermodynamic Properties of P and B in</td>
<td>49</td>
</tr>
<tr>
<td>Molten Silicon Alloys (Invited)</td>
<td></td>
</tr>
<tr>
<td>K. Morita</td>
<td></td>
</tr>
<tr>
<td>Experimental Techniques to Characterize High-Temperatures Processes</td>
<td>61</td>
</tr>
<tr>
<td>Such as the Direct Decomposition of Metal Sulfides (Invited) (Abstract Only)</td>
<td></td>
</tr>
<tr>
<td>Thermodynamic Simulation of Complex Metallurgical and Chemical</td>
<td>63</td>
</tr>
<tr>
<td>Systems with the Method of Chemical Dynamics (Invited)</td>
<td></td>
</tr>
<tr>
<td>B. Zilbergleyt and M. Zinigrad</td>
<td></td>
</tr>
<tr>
<td>Parameters for Control and Optimization of Bioleaching of Sulfide</td>
<td>77</td>
</tr>
<tr>
<td>Minerals (Invited)</td>
<td></td>
</tr>
<tr>
<td>H. Deveci, A. Akcil and I. Alp</td>
<td></td>
</tr>
<tr>
<td>Investigation of Genus Alyssum Species for Control and Optimization</td>
<td>91</td>
</tr>
<tr>
<td>of Nickel Phytoextraction Processes and Phytoremediation of Nickel</td>
<td></td>
</tr>
<tr>
<td>Contaminated Soils (Invited)</td>
<td></td>
</tr>
<tr>
<td>A. Hasko, A. Çullaj and F. Kongoli</td>
<td></td>
</tr>
</tbody>
</table>
FEEDS, FURNACES AND SLAGS

New Approach for the Optimization of Copper Concentrates Flash Combustion through the Control of the Blends and Slag Composition (Invited) (Abstract Only) ...........................................................................................................................................107
  R. Parra, F. Kongoli and R. Parada

Optimization of Coke Rate and Sinter Quality by Genetic Algorithm for Two-layer Sintering of Iron Ore .................................................................................................................................109
  N.K. Nath and K. Mitra

Examining Reheating Furnace Thermal Response to Mill Delays (Invited) ..........................................................125
  P.V. Barr

Comparison of Control Strategies for Reheating Furnaces .........................................................................................137
  C.P. Malhotra

Laser Measurement Under Tough Conditions (Invited) .........................................................................................149
  A. Dietrich, P. Kasperon and H. Sommerauer

Theoretical and Practical Aspects of Direct Recycling of Slags in E.A.F ............................................................157
  P.S. Nita

Optimization of the Reverb Furnace Slag Composition in the RTB BOR Serbia ..........................................................165
  N. Mitevska and Z.D. Zivkovic

MOLTEN MATTES, METALS AND AQUEOUS PROCESSING

Optical Spectroscopy for Process Monitoring and Production Control in Ferrous and Non-Ferrous Industry (Invited) ...........................................................................................................................................177
  W. Persson and W. Wendt

Ultrasonic Inclusion Detection and Cleanliness Measurement in Molten Aluminum and Magnesium ...........................................................................................................................................193
  Y. Ono, J.-F. Moisan, Y. Zhang, C.-K. Jen and C.-Y. Su

Accurate, Responsive Melt Rate Control During Vacuum Arc Remelting ..........................................................209
  R.L. Williamson, J.J. Beaman and D.K. Melgaard

Solidification of Melt on a Rapidly Rotating Disc in Centrifugal Atomisation (Abstract Only) ...........................................................................................................................................225
  K.H. Ho and Y.Y. Zhao

Role of CFD as a Process Monitoring and Prediction Tool for Secondary Steelmaking (Invited) ...........................................................................................................................................227
  A. Mukhopadhyay
Optimization of the Downcomer Performance of The Jameson Cell by Measuring Electrical Conductivity .................................................................241
   F.J. Tavera and R. Escudero

A Procedure for Chromate Conversion Coating of Commercial Galvanized Steel to Olive Color at Normal Temperature ..................................................253
   A.A. Mottahedi

THERMO-MECHANICAL PROCESS MODELING:
DEFORMATION, QUENCHING, CASTING AND WELDING

Mathematical Model of Formation of Cross-Sectional Wall Thickness
Variations in Tubes During Cold Plug Drawing Process .........................................................261
   G.I. Gulyayev, Y.G. Gulyayev, Y.I. Shyfrin
   and K. Sawamiphakdi

Visualizing the Evolutions of Microstructure through Quenching Processes ....................273
   M. Takahashi, Md. Maniruzzaman
   and R.D. Sisson, Jr.

Computer Simulation of Temperature and Thermal Stress Fields Generated
During Heat Treating of JIS 415 H Steel Parts .................................................................287
   H. Castillo and M.A. Neri

Effect of Agitation on the Quenching Performance of a Quench Oil using
CHTE Quench Probe System .................................................................................................297
   Md. Maniruzzaman, M.B. Stratton, T.A. Rogers,
   L.P. Barber and R.D. Sisson, Jr.

Process Control and Optimization of Near Net-Shaped Aluminum-Silicon
Alloys Premium Cast Products (Invited) ...........................................................................313
   R. Ghomashchi

Multidisciplinary Coupled Simulations of Investment Casting Processes
Using CASTS-FLUENT ........................................................................................................333
   J. Jakumeit, R. Laqua, T. Ivas, J. Scheele, M. Braun,
   A. Mukhopadhyay and M. Pelzer

Thermal Boundary Conditions For Computer Simulation Of Grey Cast Iron
Solidification in Sand Moulds .............................................................................................343
   N. Coone, D.J. Browne, M. Hussey and D. O’Mahoney

Prediction of Evolutional Stress in Friction Stir Welding ................................................357
   C.M. Chen and R. Kovacevic

Numerical Modeling of the Thermal Behavior During the LENS™ Process ....................369
   R. Ye, Y. Zhou, W. Wei, J.E. Smugeresky
   and E.J. Lavernia
MICROSTRUCTURE MODELING:
HEATING, GRAIN GROWTH AND PRECIPITATION

Cementite And Carbide Dissolution in Steels During Austenitization at High Heating Rates (Invited) (Abstract Only) ............................................................379
  T.C. Tszeng, G. Shi and S. Purohit

Process Design and Optimization for High-Temperature Vacuum Carburizing .................................................................381
  X.J. Gao, G.B. Olson, F. Stavehaug and C. Scharer

Grain Boundary Grooving by Surface Diffusion with Strong Surface Energy Anisotropy (Abstract Only) .............................................................397
  T. Xin and H. Wong

Asynchronous Parallel Potts Model for Simulation of Grain Growth .................................................................399
  P.A. Manohar and A.D. Rollett

Irregular Cellular Automata Modeling of Recrystallization and Grain Growth in an Al-killed Steel Including the Influence of AlN-Precipitation ..................413
  K.G.F. Janssens, F. Vanini and E. Kozeschnik

Competing Processes of Hardening and Softening during Strain Aging of Mild Steel .................................................................421
  I.E.A. Aghachi and H.D. Chandler

Modeling of Precipitation in Multi-Component Multi-Particle Multi-Phase Systems .................................................................429
  E. Kozeschnik, J. Svoboda, F.-D. Fischer

Simulation of Precipitation in a Complex 9-12% Cr Steel for Modern Steam Power Plants .................................................................435
  J. Rajek, E. Kozeschnik and H. Cerjak

Computer Model for Predicting Carbide Precipitation during Coiling in a Microalloyed Steel .................................................................441
  Y. Lee and Y. Cho

MICROSTRUCTURE: SOLID-STATE, COOLING PROCESSES

Prediction of Austenite Decomposition During Cooling of Low and Medium-Carbon Low-Alloy Steels .................................................................453
  E. Anelli, M.C. Cesile and P.E. Di Nunzio

Computer Simulation of The Austenite-to-Ferrite Transformation in a Fe-20%Cr-Invalid Code [Fe]-%Cr Diffusion Couple (Abstract Only) .....................................467
  A. Salwén
## CONTENTS

### PRODUCT PHYSICAL METALLURGY I

**Hot Ductility and Fracture**

- **On the Cleavage Fracture of a High Strength Maraging Steel**
  by W. Tusler, B. Jamnig, H. Leitner, O. Kolednik, R. Ebner and H. Clemens
  - Page 3

- **The Mechanism of Property Enhancement in M2 Tool Steel by Cryogenic Treatment**
  by R. M. Kelkar, P. Nash and Y. T. Zhu
  - Page 13

- **Hot Ductility and Effect of High Temperature Deformation in In-Situ Solidified Microalloyed Steels**
  by F. Zarandi and S. Yue
  - Page 21

- **Effect of Very High Temperature Deformation on Hot Ductility of a Peritectic Steel Containing Vanadium**
  by A. Rezaeian, F. Zarandi, D. Q. Bai and S. Yue
  - Page 33

- **Effects of Niobium Content and Heat Treatment on the Microstructure and Mechanical Properties of Railroad Tank Car Steel Plates**
  by P. J. Kyed, M. Manohar and R. L. Bodnar
  - Page 43

- **The Kinetics of VC Precipitation in Microalloyed Hypereutectoid Steels**
  by A. M. Elwazri, E. Essadiqi and S. Yue
  - Page 57

- **Effects of Vanadium and Silicon Additions on Microstructure and Mechanical Properties of Hypereutectoid Steels**
  by A. M. Elwazri, E. Essadiqi and S. Yue
  - Page 69

### ROLL TECHNOLOGY I

**Rolls and Rolling**

- **In Mill Measurement of Work Roll Young’s Modulus**
  by D. S. Bell
  - Page 83

- **Dofasco No. 2 Hot Mill Profile/Flatness Performance and Finishing Mill Work Roll Practices**
  by A. Monaco and G. Stephen
  - Page 89

- **A Study of the Temperature at the Interface of the Work Roll and the Thin Scale Layer on a Low Carbon Steel During Hot Rolling**
  by J. B. Tiley and J. G. Lenard
  - Page 103

- **Development and Application of High Speed Steel Rolls for Long Products**
  by M. A. Carvalho, R. R. Xavier, E. Cannizza, A. Rivaroli Jr., T. H. White and A. Sinatoria
  - Page 113

- **Development of New Backup Roll for Strip Shape Control**
  by W.-H. Lee and Y. Liu
  - Page 123

- **Carbide Enhanced High Chrome Iron and Steel Work Rolls for Rolling Flat Products**
  by K. H. Ziehenberger and M. Windhager
  - Page 133
AUTOMOTIVE SHEET STEELS I

Advanced High Strength Steels (Dual Phase and TRIP)

Development of 590 Mpa Grade High Strength Cold Rolled Steel Sheets for Automotive Structural Parts .................................................................145
  by S. J. Kim, K. G. Chin and Y. S. Jin

Aluminum Rich TRIP-Aided Steels: Effects of Alloy Additions and Processing .............................................153
  by R. Pradhan and J. P. Wise

A Family of 590 Mpa High Strength Steels with Various Microstructures .............................................173
  by D. Bhattacharya, N. M. Fonstein, O. A. Girina, I. Gupta and O. Yakubovsky

Effect of Boron Addition on the Microstructure and Mechanical Properties of Hot Rolled Low Carbon Steels.................................................................187
  by Y. R. Cho, S. I. Kim and B. S. Seong

Bake Hardenability of Multiphase High Strength Automotive Sheet Steels ..........................................195
  by B. M. Hance, T. M. Link and D. P. Hoydick

PRODUCT PHYSICAL METALLURGY II

Recrystallization and Precipitation

Physical and Numerical Modeling of Plastic Deformation of Steels in Two-Phase Region .................209
  by M. Pietrzyk, R. Kuziak and T. Kondek

Mathematical Modeling of Austenite Conditioning During Hot Strip Rolling at Usiminas .................221
  by A. A. dos Santos, T. M. F. Melo and R. M. Alé

The Influence of α→γ Transformation on the Grain Coarsening Temperature of Ti-Nb Microalloyed Steels ...............................................................................................................................231
  by P. A. Manohar and T. Chandra

The Nucleation of Ferrite from a Coarse Grained Austenite During the Slow Continuous Cooling of an HSLA Steel .........................................................................................................................243
  by W. Gao, C. I. Garcia and A. J. DeArdo

Study of the Austenite Decomposition in Low Carbon Steels with Microalloy Additions .................257
  by M. Buhler, G. R. Gomez and T. Perez

Aging of Medium-C Martensite and High-C Mestastable Austenite: A Neutron Diffraction Study .....269
  by L. Barbé, T. Waterschoot and B. C. DeCooman

ROLL TECHNOLOGY II

Equipment

Connecting the Roll to the Power Train — The Roll End Casing .................................................................283
  by J. M. Senne

Monolith Design — Roll Grinder Technology ...............................................................................................293
  by J. Rupp
Roll Cool-Down Facility at the ISG Burns Harbor HSM .................................................................301
  by B. Bramfitt and R. Perry
Portable Hardness Testing in the Iron-Steel Industry ........................................................................309
  by M. Kompatscher
Case at EKO Stahl Where Combined Eddy Current (ET)/Ultrasonic (UT) Roll Inspection
  Minimizes the Number of Major Mill Accidents ...........................................................................317
  by M. Schönfeld and R. J. W. M. van Kollenburg

AUTOMOTIVE SHEET STEELS II

Fatigue and Welding of High Strength Steels

Friction Stir Welding of Dual-Phase Sheet Steel ................................................................................327
  by M. P. Miles and T. W. Nelson
On the Spot Welding Behavior of Galvannealed Steel Trip for Automotive Applications ..................333
  by J. A. Nieto, M. P. Guerrero-Mata, R. Colás, A. Mani and R. Garza
Tensile-Shear Spot Weld Fatigue Behavior of High Strength Steels ......................................................345
  by T. M. Link
Metallurgical Aspects of the Fatigue Performance of Soft and High Strength IF Steels .......................359
  by R. Koenis, A. Pichler and C.-P. Reip
Fatigue Performance of IF and High Strength IF Steel Grades ...........................................................371
  by A. Pichler, K. Thaller, C.-P. Reip and R. Koenis

PRODUCT PHYSICAL METALLURGY III

Effect of Processing on the Ferrite/Austenite Phase Transformation

Phase Transformation and Processing of High Strength Steel ............................................................391
  by E. Essadiqi, B. Voyzelle, V. Kao, C. Galvani, M. T. Shehata and H. Kobayashi
Effect of Annealing Parameters on Austenite Decomposition in a Continuously Annealed
  Dual-Phase Steel .................................................................................................................................403
  by O. A. Girina, N. M. Fonstein and D. Bhattacharya
Effect of Mn on the Stability of Austenite in a Continuously Annealed Dual-Phase Steel ....................415
  by O. A. Girinina and D. Bhattacharya
Effect of Annealing Parameters on the Structure and Properties of Intercritically Annealed
  Steels Intended for Hot Dipped Dual-Phase Applications ..................................................................421
  by D. P. Hoydick and D. M. Hezebruck
Properties of Austenite in Microalloyed C-Mn-Al-Si-P TRIP Steels ....................................................437
  by D. Krizan, J. Antonissen, L. Barbé and B. C. DeCooman
LONG PRODUCTS

Cold Drawing of Tubes on a Movable Mandrel .................................................................451
by G. I. Gulyayev, A. I. Lobanov, V. V. Sergeyev and C. V. Darragh

User-Oriented Three-Dimensional Finite Element Modeling of High Speed Bar and Rod Rolling ......461
by S. Biswas, J. J. Rencis, H. Gutierrez and B. V. Kiefer

Development of Direct Annealing Treatments After Hot Working in Alloyed Steels..................471
by R. Abad, B. Lopez and J. M. Rodriguez-Ibabé

Bar and Rod Mill Modeling System for Improved Roll Pass Design and Process Selection ..........481
by H. Gutierrez and B. V. Kiefer

AUTOMOTIVE SHEET STEELS III

Formability and Bake Hardenability of High Strength Steels

Effects of Microstructure on Stretch-Flange-Formability of Cold Rolled Ultra
High Strength Steels ........................................................................................................495
by K. Hasegawa, K. Kawamura, T. Urabe and Y. Hosoya

Evolution of Deformation-Induced Surface Morphologies Developed in Fe-Based Sheet Metals......507
by M. R. Stoudt, S. W. Banovic and T. Quarrick

Effects of Chemical Compositions and Processing Conditions on Mechanical Properties of
Ti-Nb Added Interstitial Free High Strength Steel (IF-HSS) ..................................................519
by H. Kang, S. Han and Y. Chin

Effect of Heat-to-Coat Treatments on the Properties and Microstructure of High Strength Hot
Rolled Steels .........................................................................................................................527
by S. Dionne, B. Voyzelle, V. Y. Gertsman, E. Essadiqi, J. McDermid, E. Baril and F. Goodwin

Galvannealing Cycles Effects on Substrate/Coating Interfacial Structures Observed by
Mössbauer Spectroscopy .....................................................................................................539
by M. Zmrzly, O. Schneeweiss, Y. Houbaert and J. Fiala

Routine Analysis of Chemistry, Microstructure and Texture of the Inhibition Layer on Hot Dip
Galvanized Steel ..................................................................................................................551
by E. J. Petit, J.-S. Lecomte and B. Gay

Simulation of Oil-Canning Tests on Closure Assemblies .....................................................563
by S. Laxman and T. Chang

FLAT ROLLED PRODUCTS

Flat Rolling and Modeling

Strip Shape Simulation Software for Continuous Cold Rolling Process ....................................577

Development of Surface Structures on Austenitic Stainless Steels Under Conditions Simulating
Hot Steckel Rolling ..............................................................................................................593
by S. J. Cobo, E. J. Palmiere and W. M. Rainforth

Columnar Structure in Hot Bands Formed by the $\alpha_T$ Transformation During Hot Working ........605
by K. Kim, G. Kim, J. H. Beynon and C. M. Sellars

Numerical Modeling of Induction Heating of Steel Bars in POSCO Thin-Slab Rolling Process ........617
by H.-J. Kim, W. C. Chung and H.-D. Park
## TABLE OF CONTENTS

Preface.......................................................................................................................................... ix

### POWDER AND PARTICULATE MAKING AND PROCESSING

**Analysis of Gas Recirculation Flow Effects in the Melt Feeding Zone of a Close-Coupled Gas Atomization Nozzle** ................................................................. 3  
I.E. Anderson, R.L. Terpstra and R. Figliola

**The Effect of Swirl on Gas Velocity Decay in a Generic Annular Close-Coupled Nozzle** ......................................................................................................................21  
S.P. Mates, F.S. Biancaniello and S.D. Ridder

**Reduced-Scale Gas Atomizer Facility for Rapid Solidification Studies (Abstract Only)** ............................................................................................................................29  
F.S. Biancaniello, S.P. Mates, and S.D. Ridder

**Argon Atomizated Powder Astaloy for Jet Engine Discs (Abstract Only)** .........................31  
L.M. Bianchi

**Metallic Filters for Hot Gas Clean-Up** ....................................................................................33  
R.L. Terpstra, I.E. Anderson and B. Gleeson

**Thermal Plasma Processing of Boron Carbide Fine Powders** .............................................47  
N.R. Thakkar and R.G. Reddy

**Solid State Processing of AZ31 Alloy from Machined Chips (Abstract Only)** ....................61  
T. Luangvaranunt, K. Kondoh and T. Aizawa

### SINTERING

**Numerical Simulation of Shape Changes During Cemented Carbide Sintering** .................. 65  
A. Petersson and J. Ågren

**Oxidation of Fuel Cell Interconnect Alloys Produced by Powder Extrusion (Abstract Only)** ....................................................................................................................77  
B.C. Church, T.H. Sanders, Jr., and J.K. Cochran

**Hydrogen Sorption Properties of Mg-x wt.% Mm Alloys** .....................................................79  
N.E. Tran and S.G. Lambrakos
Shock Compaction of Exchange-Coupled Bulk Nanocomposite Magnets
(Abstract Only) .................................................................................................................................91
   Z.Q. Jin, K.H. Chen, J. Li, G. Kennedy, H. Zeng,
   S.-F. Cheng an Z.L. Wang

Present Status and Future Potential of Sinter-Forging Technology .................................................93
   S. Kumar and A.K. Jha

Interfacial Friction During Mechanical Processing of Sintered Metal Powder Preforms ............................................................107
   S. Kumar, A.K. Jha, M. Agarwal and R.K. Singh

Nanostructured Bulk Cu Obtained by Consolidation of Cu Particles Using Equal Channel Angular Extrusion .................................................................125
   M. Haouaoui and I. Karaman

IN-SITU REACTIONS FOR SYNTHESIS AND DENSIFICATION

Microstructure and Strength of Shock Synthesized and Densified Tungsten Heavy Alloys ........................................................................................................................................141
   F.D.S. Marquis and A. Mahajan

Production of Nanophase Metals via the Continuous Microwave Polyol Process .................................................................157
   D. Lewis, M.A. Imam, R.W. Bruce, L.K. Kurihara,
   A.W. Fliflet and S.H. Gold

Mechanical Alloying for Advanced Materials .................................................................................................169
   C. Suryanarayana and E. Ivanov

Fabrication of Bulk Nanocomposite Magnets by Nano-Powder Metallurgy ..............................................179
   J.P. Liu

Synthesis of Advanced Ceramic Composites (Abstract Only) .................................................................187
   O. Okrostsvardze, F.D.S. Marquis, G. Tavadze,
   A. Khvadagiani and D. Sachvadze

Influence of Neutron Irradiation on Shock Wave Strengthened Titanium and Copper (Abstract Only) .................................................................................................................................189
   N. Chikhradze, F.D.S. Marquis, E.S. Lapiashvili,
   M.T. Asatiani and A.B. Peikrishvili

Explosive Compaction/Cladding of YBCO Discs: A Numerical Approach .................................................................191
   A.G. Mamalis, I.N. Vottea, D.E. Manolakos,
   A. Szalay and F.D.S. Marquis
Coating of SWNTs with Nickel by Electroless Plating Method
(Abbreviation Only) ..........................................................................................................................199
  O. Zeng, Y. Bayazitoglu and E.V. Barrera

RAPID PROTOTYPING AND RAPID MANUFACTURING

Selective Laser Polishing Surface Phenomenology in Fe-Cu Indirect SLS Products (Abstract Only) ..........................................................................................................................203
  J.A. Ramos and D.L. Bourell

Slurry Extrusion and Laser Densification in Rapid Prototyping for Dental Restoration (Abstract Only) ..........................................................................................................................205
  L.L. Shaw, X. Li and J. Wang

Rapid Materials Prototyping as a Combinatorial Materials Science Tool (Abstract Only) ..........................................................................................................................207
  R. Vilar

Laser Powder Deposition of Titanium Engine Exhaust Valves with Wear Resistant Coatings (Abstract Only) ..........................................................................................................................209
  J.W. Sears, E. Pollard, M. Moberg, N. Wald,
  V. Johnson and F.D.S. Marquis

Development of Laser-Powder Additive Manufacturing for Industry: Historical Perspective, Current and Future Applications ...............................................................211
  J.W. Sears

Microstructural Observations of 316L Stainless Steel Laser Powder Depositions ..........................................................................................................................229
  S.K. Koduri, E. Henderson, A.C. Costello
  and J.W. Sears

Laser Enhanced Thermal Spray Coatings ............................................................................239
  V. Loganathan, C.H. Jenkins, C. Allen
  and J.W. Sears

Structure of MCrAlY Laser Cladding Coatings Deposited on Single Crystal Alloy Turbine Blades ..........................................................................................................................247
  P.N. Ferreira, R. Vilar, J.P. Pina, R.C. da Silva,
  A.D. Sequeira and F.D.S. Marquis

Qualification of Model Based LENS™ Materials Processing (Abstract Only) ..........................................................................................................................259
  J.E. Smugeresky, R. Grylls, D.M. Keicher
  and C. Robino
STRUCTURE/PROPERTIES/PROCESSING RELATIONSHIPS

An Overview of Current Research and Industrial Practices of Be Powder Metallurgy (Abstract Only)........................................................................................................263
  J.C. Foley, S.P. Abeln, P.W. Stanek, B.D. Bartram, V.D. Vargas and B. Aikin

Structure and Properties of Consolidated Amorphous Metal Powder .........................265

Instrumented Mechanical Alloying of a Novel Superalloy Powder..................................273
  M.G. McKimpson and M. King

Double Cemented Carbide – Microstructural Model of Toughness
(Abstract Only) ....................................................................................................................291
  X. Deng, T. Tang, N. Sun, A. Griffo and J.W. Bitler

Powder-Derived High-Conductivity Coatings for Copper Alloys ....................................293
  L.U. Ogbuji

Increased Processing Options and Properties of Molybdenum 41% Rhenium as a Result of Powder Modification .................................................................301
  D. Mitchell, T. Leonhardt, J. Downs and N. Moore

Precast Refractory Systems: The Furnace Lining Systems for the Future
(Abstract Only) ..................................................................................................................315
  D. Quilter

Author Index .......................................................................................................................317
# Table of Contents

**Preface**........................................................................................................................................ ix

## Modeling and Simulation

**Are Deformation Mechanisms Different in Nanocrystalline Metals?**
Experiments and Atomistic Computer Simulations (Invited)........................................................3
  *H. Van Swygenhoven, Z. Budrovich, P.M. Derlet and A. Hasnaoui*

**Yield Stress of Nanocrystalline Materials:**
Role of Grain Size Distribution ...................................................................................................11
  *C.S. Pande and R.A. Masumura*

**Effect of Grain Size Distribution on the Mechanical Behavior of Ultrafine-Grain Metals**
........................................................................................................................................................19
  *S. Cheng and W.W. Milligan*

**Strength Design of Maps for Nanolayered Composites** ............................................................27
  *A.V. Lamm and P.M. Anderson*

**Molecular and Atomic Polarizabilities of Model Carbon Nanotubes** ........................................35
  *F. Torrens*

## Structure and Property Relationships

**Grain Size Distribution and Mechanical Properties of Nanostructure Materials (Invited)**
........................................................................................................................................................45
  *C.C. Koch and R.O. Scattergood*

**Dependence of Microhardness on Internal Strains of Nanocrystalline Al Alloy**
........................................................................................................................................................53
  *L. Shaw, J. Villegas, H. Luo and D. Miracle*

**Experiments and Modeling of the Surface Nanocrystallization and Hardening (SNH) Process**
........................................................................................................................................................61
  *J. Villegas, K. Dai, L. Shaw and P. Liaw*

**Bulk Nanostructured Materials Produced by Mechanical Alloying and Spark Plasma Sintering (Invited)** ........................................................................................................................................ 69
  *J.G. Cabañas-Moreno, H.A. Calderón, O. Coreño-Alonso, M. Umemoto, K. Tsuchiya and J.R. Weertman*
The Effects of Equal Channel Angular Pressing on Microstructure and Tensile Properties of Spray Deposited Al-Cu-Mg Alloy ........................................................................................................ 77

Elevated Temperature Deformation Behavior of Nanostructure Al-Ni-Gd Alloys .......................................................................................................................... 85
X.L. Shi, R.S. Mishra and T.J. Watson

Mechanical Properties of Ultrafine-Grained Titanium Aluminide/Titanium Silicide Composites Prepared by High Energy Milling (Invited) .................................................................................................. 93
T. Klassen, R. Bohn, C. Suryanarayana, G. Fanta and R. Bormann

Mechanical Properties/Microstructure Correlation in a Devitrified Fe-Based Metallic Glass .................................................................................................................. 101
N.A. Mara, A.V. Sergueeva and A.K. Mukherjee

Grain Size Effects in Nanocrystalline Electrodeposits (Invited) ........................................ 109

Processing-Controlled Mechanical Properties and Microstructures of Bulk Cryomilled Aluminum-Magnesium Alloys (Invited) ........................................................................ 117
D. Witkin and E.J. Lavernia

Nanocrystallization of Steels by Various Severe Plastic Deformation ......................... 125
M. Umemoto, Y. Todaka and K. Tsuchiya

Mechanical Properties and Fracture Mechanism of Nanostructured Al-20 wt% Si Alloy .................................................................................................................. 133
S.-J. Hong and C. Suryanarayana

High-Strength, High Conductivity Bulk Nanostructured Ag-Cu Alloys (Invited) .............. 141
R.B. Schwarz and T.D. Shen

Optical and Nanochemical Characterization of a Tin Sulfide-Silica Multilayer System .................................................................................................................. 149
M. Deopura, Y. Fink and C.A. Schuh

Processing of Mechanical Properties of Bulk Nanocrystalline Ni-Fe Alloys (Invited) .... 157
J.S. Lee, X.Y. Qin, S.K. Kwon and Y.S. Kang

Processing and Microstructure Development

Microstructural Investigation of Nanocrystalline Bulk Al-Mg Alloy Fabricated by Cryomilling and Extrusion .......................................................... 167
Y.S. Park, K.H. Chung, N.J. Kim and E.J. Lavernia
Nanocrystalline Microstructure and Defects in Al Solid Solution Subjected to Surface Mechanical Attrition Treatment .................................................................175
    J. Hui, X. Wu, N. Tao, Y. Hong, J. Lu and K. Lu

Fabrication of Bulk Nanostructured Materials by Friction Stir Processing .....................181
    J.-Q. Su, T.W. Nelson and C.J. Sterling

Investigations of Glassy and Nanostructured Metal-Metal Type Alloys .......................189
    D.V. Louzguine, S. Ranganathan and A. Inoue

Nanocrystal Formation by Crystallization of Zr_{52}Ti_{6}Al_{10}Cu_{18}Ni_{14} Bulk Metallic Glass .................................................................197
    G.K. Dey, R.T. Savalia, S. Neogy, D. Srivastava,
    R. Tewari and S. Banerjee

Crystallization Behavior of an Amorphous Al_{85}Ni_{10}La_{5} Alloy ....................................205
    Z. Zhang, D. Witkin and E.J. Lavernia

Texture Evolution in Nanocrystalline Fe-36wt%Ni Alloy Foil ......................................213
    J.H. Seo, J.K. Kim and Y.B. Park

Author Index ......................................................................................................................219