# TABLE OF CONTENTS

## AISTech® 2021

### Volume I

#### SAFETY & HEALTH

**Making the Steel Industry Safer Through Digitalization**

Virtual Reality Simulator for Portable Fire Extinguisher Training .......................................................... 1  
*Justin Heffron, Chenhao Zhang, John Moreland, Kyle Toth, Angela Hiller, Jeff Mitchell, Robbie Britton, Stephen Borzych, Chenn Zhou*

Smart Safety Guard — Improving Safety Through Real-Time People Localization ........................................ 8  
*Nicolas Schlesser, Fabrice Hansen, D. Jakubowski, Yves Reuter*

**Safety Innovations in Equipment and Behavioral Tools**

Managing the Impact, Assessment and Application of Solutions for Combustible Dust Mitigation and Control in Modern Manufacturing Environments ........................................................................ 17  
*Simon Shipp*

Managing Heat Stress-Related Injuries and Illness in the Iron and Steel Industry ........................................... 33  
*Rupkatha Bardhan, Melina Eaker, William Ryan Gaskins, Jacob Crissup*

A Holistic Approach Toward the Next Level of Safe EAF Operation ............................................................ 41  
*Danny Schreiber, Andreas Volkert, Ralf Schweikle, Sven Fuchs, Patrick Hansert, Cara Riedel*

#### SAFETY & HEALTH/MATERIAL HANDLING/TRANSPORTATION & LOGISTICS

**Safety & Health/Material Handling/Transportation & Logistics**

Steeled for Safety: Visual Aid Technologies to Increase Safety With Material Handling ................................. 46  
*Christopher Machut*

Material Flow How Concept for Steel Plants and Warehouses ...................................................................... 50  
*Juha Suksi, Samu Katkanaho, Jagannathan Rajagopalan*

#### ENVIRONMENTAL

**Emissions Control I**

Case Study: System Modifications Enhance Overall Ventilation Systems ................................................... 65  
*Ray Tedford*

Modern Blast Furnace Top Gas Cleaning: Wet Separation Improvements at U. S. Steel – Great Lakes Works B2 Blast Furnace ........................................................................................................... 76  
*Jean-Luc Kuffer, Jim Quick, Christian Davidi*
Environment Defines Productivity: Emission Control System Modifications Using Fluid Dynamic Study of Building Ventilation at Sinobras Meltshop, Brazil ................................................................. 86
Jim Belous, Milton Lima

Emissions Control II

How U.S. Steelmaking Became a Green Industry and What Lies Ahead ................................................................. 97
Francesco Memoli

Review of Centrifugal Fan Design Decisions Over the Past 25 Years of Operation .................................................... 129
Sean Graham, Steve Back, Mike Schlenmer, Dan Banyay

IRONMAKING

Blast Furnace Digitization, Control & Modeling

Optimization of Parameters of Blast Furnace Smelting Under Conditions of Plant Operation With Limited Supply of Coke, Natural Gas or Iron-Bearing Materials ................................................................. 139
Michael Alter

Machine Learning for Blast Furnace Productivity Improvement at Jindal Steel and Power Angul ......................... 147
Anil Gandhi, Ritesh Misra, Aniruddha Fadnis, Richa Jaiswal, Sambit Mishra, Amitava Sircar

Numerical Study of Heat Transfer for Microwave-Assisted Reduction of Hematite ................................................. 158
Prasenjit Singha, Sunil Yadav, Soumya Ranjan Mohanty, Ajay Kumar Shukla

Blast Furnace Injection & Stove Technologies

Investigation of High-Rate and Pre-Heated Natural Gas Injection in the Blast Furnace ...................................... 168
Samuel Nielson, Tyamo Okosun, John D’Alessio, Shamik Ray, Mitchell Klaas, Chenn Zhou

Techno-Commercial Reasons to Invest in Hot Blast Stoves .................................................................................. 180
Mark Geach, John Croot

Blast Furnace Operation Improvement by Forming Uniform Circular Distribution of Raceway's Thermal Mode ................................................................................................................. 184
Yuriy Semenov, Viktor Horupakha, Evgen Shumelchyk, Michael Alter

Blast Furnace Relines, Repairs & Restarts

Ironmaking in Russia ............................................................................................................................................. 193
Yakov Gordon, Dmitriy Tikhonov, Dina Vorsina, Alexey Tretyak

Raw Materials

Addition of Scrap and DRI/HBI to the Blast Furnace — Technology to Overcome Top Temperature Limits and Reduce Greenhouse Gas Emissions .................................................................................. 205
Ian Cameron, Don Tu, Mitren Sukhram, Janice Bolen, Jennifer Woloshyn

Cold-Bonded Briquette Testing Methodology and Standards Used for Traditional Furnace Feedstocks ......................... 217
Mac Steele, Mark T. Ford
DIRECT REDUCED IRON

DRI Plant Operations & Digital

Investigation of Carbon Deposition During Natural Gas and Oxygen Injection for the Direct Reduction Ironmaking Process .......................................................... 227
Tyamo Okosun, Yu Wang, Qurram Syed, Elaine Chen, Rui Liu, Cesar Velazquez, Joel Carmona, Chenn Zhou

Rising and Failure of Gas-Based Direct Reduction Processes .......................................................... 237
Yakov Gordon

Hydrogen-Based DRI

Hydrogen-Based DRI EAF Steelmaking — Fact or Fiction? .......................................................... 249
Sara Hornby

MIDREX H2 — The Road to CO2-Free Iron and Steelmaking .......................................................... 262
Robert Millner, Johannes Rothberger, Barbara Rammer, Christian Boehm, Wolfgang Sterrer, Hanspeter Ofner, Vincent Chevrier

Searching New Horizons: The Hydrogen Revolution in Steelmaking ............................................ 274
Paolo Argenta, Francesco Memoli

ELECTRIC STEELMAKING

EAF Energy

Sunday Abraham, Yufeng Wang, Randy Petty, Tim Sprague, Tony Franks, Eric Brown

Implementation of the Tiltable Sidewall Burner at Nucor Steel Tuscaloosa Inc.: Dynamically Adjustable Burner Angle to Optimize Scrap Melting and Reduce Refractory Wear .............................................. 297
Justin Novotny, Ryan Junkin, Michael Mayhall, Jake Franks, Phil Baker, Patrick Hansert, Fatih Goekce

Application of JetBurner Technology for a Small-Sized EAF ...................................................... 307
Juergen Jung, Taras Gabriel, Adam Partyka, Martin Pavliš

EAF Performance I

Bath Level Management in the Consteel DC Electric Arc Furnace .............................................. 317
Pat Quiney, Kaleb Fitch, Paul Turner, Leonard Meads

The EAF for Integrated Plants ......................................................................................................... 330
Jens Apfel

EAF Performance II

Numerical Investigation of DC Electric Arc Behavior Under the Consideration of Electrode Movement ............................................................................................................. 339
Yuchao Chen, Yu Wang, Armin Silaen, Chenn Zhou
OXYGEN STEELMAKING

Improvving Performance & Control

Novel Method for Stirring BOF Melts in Conjunction With Slag Splashing ......................................................... 348
Anand Makwana, Anup Sane, Xiaoyi He, Gregory Buragino

Installation of Vaicon Slag Stopper at U. S. Steel – Great Lakes Works ................................................................. 357
Ernesto Serrano, Gerald Wimmer, David Runner, Yun Li, Denis Vaillancourt, Michael Maringer

Ladle Hot Spot Detection — A Novel and Robust Approach to Eliminate False Positives in Infrared Thermal Image Analysis ........................................................................................................... 366
Miguel Simiand, Javier Barreiro, Ignacio Salinas

Operational Practices & Issues

Spray-Cooled BOF Hoods at U. S. Steel – Gary Works: 28 Years .................................................................................. 373
Louis Valentas, Troy Ward

Revamp of BOF Converters at AK Steel–Middletown Works Using Vaicon Link 2.0 Converter
Vessel Suspension System .................................................................................................................................................. 383
Steve Torok, Gerald Wimmer, Georg Unterrainer, Denis Vaillancourt

Increased Safety and Performance of BOF Relining at Ternium Brasil ......................................................................... 392
Leonardo Demuner, Bernhard Voraberger, Willian Correa, Gerald Wimmer

SPECIALTY ALLOY & FOUNDRY

Specialty Alloy & Foundry

Effect of RE Master Alloys on AISI 1030 Steel ................................................................................................................. 400
Robert Tuttle

LADLE & SECONDARY REFINING

Ladle & Secondary Refining: I

Analysis of Inclusion Clusters Using Machine-Learning Tools .......................................................................................... 414
Mohammad Abdulsalam, M. Jacobs, Bryan Webler

Smart Ladle: AI-Based Tool for Optimizing Casting Temperature ....................................................................................... 428
Nicholas Walla, Zhankun Luo, Bin Chenn, Yury Krotov, Chenn Zhou

Ladle & Secondary Refining: II

The Effects of Non-Metallic Inclusions on Charpy V-Notch Toughness ............................................................................ 436
Sunday Abraham, Rick Bodnar, Eric Lynch, Yufeng Wang

A Comparison of the Dynamics, Mixing Efficiency and Ladle Wall Wear in Gas-Stirred Ladles ............................. 448
Pavan Kumar Shivaram, Markus Gruber, Tyler Spudic
CONTINUOUS CASTING

Casting Technologies & Process Improvements

High-Throughput Casting Technology — Challenges and Solutions .................................................. 459
  Juergen Mueller, Christian Froehling, Frank Seuffert

A Fiber-Optic-Distributed Temperature Mapping Technique to Characterize Shell Solidification in Peritectic-Grade Steels .................................................................................................................. 465
  Damilola Balogun, Muhammad Roman, Laura Bartlett, Ronald J. O'Malley, Rex Gerald, Jie Huang

Digital Technologies for Continuous Casting .......................................................................................... 474
  Gianluca Maccani, Vittore Girardin

  Yizhou Du, Ronald J. O'Malley, Mario Buchely, Mingzhi Xu

Mold Behavior

A Potential Application for Utilizing Adaptive Mesh Refinement in a Continuous Caster Simulation .................................................................................................................................................. 485
  Matthew Moore, John Resa, Xiang Zhou, Haibo Ma, Armin Silaen, Chenn Zhou

Modeling of Air-Mist Spray in Continuous Casting of Steel ........................................................................ 497
  Vitalis Ebuka Anistuba, Haibo Ma, Armin Silaen, Chenn Zhou

New Installations & Modernizations

Safe, Fast and Cost-Effective Caster Roll Change at SDI Butler .............................................................. 508
  Tobin Smith, John Hook, Herb Pattison

CONTINUOUS CASTING/METALLURGY — STEELMAKING & CASTING

Continuous Casting/Metallurgy — Steelmaking & Casting

Reduction of Transverse Corner Cracks During Continuous Casting of Slabs ........................................ 517
  Yufeng Wang, Miles Haberkorn, Dallas Brown, Sunday Abraham, Randy Petty

Hot Ductility Behavior of V-N Microalloyed Steels .................................................................................. 528
  Madhuri Varadarajan, Laura Bartlett, Ronald J. O'Malley, Simon Lekakh, Mario Buchely

Reducing Corner Cracks With a New Strategy for Secondary Cooling .................................................. 540
  Paul Pennerstorfer, Andreas Mittermair, Se-Ho Lim, Won-jae Cho

HOT SHEET ROLLING

Emerging Technologies

A Thermomechanical-Microstructural Model of a Hot Strip Mill .......................................................... 547
  Eugene Nikitenko, Susan Farjami
Inspection of Rolled Heavy Plate by 3D Inspection

Dominik Recker, Greg Gutmann

Revolutionary Endless Strip Production up to 20 mm — Precise and Uniform HSLA Steel

K. Baumgartner, T. Lengauer, S. Grosseiber, Andreas Jungbauer

Power Cooling — Advanced Strip Cooling Technology for Hot Strip Mills for Maximum Metallurgical Flexibility, High Cooling Rates and for Saving of Alloying Elements

Lukas Pichler, Konrad Krimpelstaetter, Ruediger Doell, Klaus Weinzierl

Measuring Flatness of Rolled Strips Under Tension in Hot Rolling Mills

Frank Gorgels, Olaf Jepsen, Patrick Siemann, Mark Zipf

New Capabilities & Product Quality

Descaling of Medium C and High Si, Mn Steels

Richard Osei, Simon Lekakh, Ronald J. O'Malley, Lesli Peterson, Oldair Sasso

Prediction of Damage During Different Hot Rolling Schedules of Medium-Carbon V-Microalloyed Steel

Showvik Ganguly, Mario Buchely, F. Okanisioppe, K. Chandrashekhara, Simon Lekakh, Ronald J. O’Malley, J. Heerema

Application of Oxygen-Enriched Combustion in an Industrial Reheating Furnace Using CFD

Bethany Worl, Francisco Martinez, Armin Silaen, Kurt Johnson, Larry Fabina, Kelly Tian, Joe Maiolo, Chenn Zhou

The Widest ESP Line for U. S. Steel — Full Digitalization Possibilities

Andreas Jungbauer, Klaus Jax, Roman Winkler, M. Ringhofer, Michael Weinzierl, Klaus Frauenhuber, Adnan Covic, B. Voglmayr, A. Haschke, A. Maierhofer

On-Line Monitoring System to Detect Anomaly of Rolls in Rolling Mills

Yuki Okano, Hiroyuki Imanari, Kazuyuki Maruyama, Yukihiro Yamasaki

Volume II

COLD SHEET ROLLING

Cold Sheet Rolling: I

Fine-Scale Details Within the Roll Clusters of 20-High/Sendzimir Mills, Part 1: Micro-Static Interactions

Mark Zipf

Fine-Scale Details Within the Roll Clusters of 20-High/Sendzimir Mills, Part 2: Micro-Dynamic Interactions

Mark Zipf

Lightweight Work Roll Flattening Model for Severe Rolling Conditions

Brian Braho, Robert Paul Schaeffer

Innovative Roll Profile Design for Thin-Strip Cold Rolling Mills

Navneet Singh, Satish Kumar Tripathi, Manish Kumar, Amit Sharma, Vidyadhar Kelkar
**Cold Sheet Rolling: II**

Transverse Flux Induction Heating Technology and High Flux Inductors ..................................................... 702  
*Emmanuel Patard, Tony Kezer, Kevin Bertermann*

Key Technologies Supporting the Production of NGO Electrical Steels .......................................................... 709  
*Toru Nakayama, Konrad Krimpelstaetter*

Cold Rolling Mill Technologies for Electrical Steel ......................................................................................... 722  
*Akihiro Yamamoto*

**GALVANIZING**

**Galvanizing**

New High-Performance X-Ray Coating Weight Gauge for Metals ................................................................. 730  
*Jean-Jacques Florent, Ian Gaudaen, François Legrand, Roland Gouel*

Physical Modeling for Product Development and Performance Optimization in Hot Dip Galvanizing Lines ................................................................................................................................. 743  
*Ben Reed, Luis Fellipe Simoes, Dennis McHugh, C. Isaac Garcia*

**PLATE ROLLING**

**Plate Rolling**

Advanced Cooling Technology to Improve High-Strength Plate-Steckel Mill Steel Production ...................... 752  
*Ian Robinson, Joachim Kilato, Dengqi Bai, Chase Rawlinson*

Evaluation of Mechanical Behavior Shifting of API 5L X70M Skelp Through Accelerated Cooling and Spiral Forming Processes .............................................................................................................. 762  
*Qiulin Yu, Jacob Lewis, Matt Montgomery, Pn Mahida, Ashish Singh*

Production of X70 Discrete Plate Using MULPIC .............................................................................................. 774  
*Dengqi Bai, Chase Rawlinson, Kenneth Hodges, Ian Robinson*

Modernization and Customization of a Copper Plate Mill Descale System ...................................................... 786  
*Steve Demar*

AI Application to Front-End Bending Prediction ................................................................................................. 792  
*Marcelo Saparrat, Fernando Monti, José Ibarra*

**LONG PRODUCTS**

**Long Products: I**

Achieving Successful Laser Velocimeter Measurements for Unguided Products Using New Innovative Technology for Tension Control of Wire Rod in Hot Rolling ................................................................................... 800  
*Jerome Dapore, D. R. Parra Solís, H. Santoyo Avilés, I. Chávez Mendoza, J. J. Cerón González*

Material Flow How® Concept for Wire Rod Coils .............................................................................................. 812  
*Juha Suksi, Jagannathan Rajagopal, Samu Katkanaho*
METALLURGY — STEELMAKING & CASTING

Improvement of Centerline Segregation at United States Steel Corporation’s Gary Works No. 2 C Line Continuous Caster ................................................................. 819
*Ernesto Serrano, S. McCann, William Schlichting, M. Keel, C. Paynes, M. Liedtke, Thinium Natarajan, B. Flanigan, C. C. Tomazin, M. Knights, M. Fornasier*

100% In-Process Compositional Testing Using X-Ray Fluorescence ................................................................. 827
*Alex Thurston*

Prediction of Inclusion GSV: A Quality Control Tool for Inclusion SEM Analysis .................................................. 834
*Mohammad Abdulsalam, Bryan Webler*

Data-Driven Study of Desulfurization During Ladle Treatment and Its Impact on Steel Cleanliness ............ 845
*Stephano Piva, P. Chris Pistorius*

Computational Studies and Optimization of Inclusion Removal in a Steel Ladle .................................................. 858
*Xipeng Guo, Joel Godinez, Nicholas Walla, Armin Sillaen, Helmut Oltmann, Vivek Thapliyal, Abhishek Bhansali, Eugene Pretorius, Chenn Zhou*

METALLURGY — PROCESSING, PRODUCTS & APPLICATIONS

Developments in Steel Processing

Non-Linear Bending Control for Temper Mills ................................................................. 874
*Brian Braho, Robert Paul Schaeffer*

Fundamentals of Alloy and Processing Design for the Successful Production of Ferritic, TiC-Strengthened Ultrahigh-Strength 100-ksi (Yield Strength) Hot-Rolled Steel With Low-Temperature Toughness Through a Flex Mill ................................................................. 884
*Chirag Mahimkar, Venkata Natarajan, V. S. Y. Injeti, Jay Martin, Denis Hennessy, Amar De*

Physical Metallurgy of Steels I

Process and Physical Metallurgical Developments for High-Performance Niobium-Containing Pressure Vessel Steel Plates ................................................................. 896
*Steven Jansto*

Development of ASTM A709-50WF Heavy Plate for Fracture Critical Bridge Applications ......................... 909
*Dengqi Bai, Yufeng Wang, Liz Peterson, Chase Rawlinson, Chris Amsden*

Effect of Through-Thickness Microstructural Homogeneity on Fatigue Performance of Structural Steels in Air and Hydrogen Environments ................................................................. 924
*Douglas Stalheim, Andrew Slifka, Enrico Lucon, Pello Uranga, Dong-hoon Kang*

Yield Stress in Ferritic Steels Influenced by Grain Boundary Walls ................................................................. 935
*Thomas L. Altshuler*

Effects of Steel Composition and Reheating Temperature on Prior Austenite Grain Size .......................... 949
*Dengqi Bai, Hanok Tekle, Jacob Mineart, Eric Lynch*
Physical Metallurgy of Steels II

Approach to Successful Production of Very-Low-Carbon High-Strength Galvanized Dual-Phase Steels Through a CSP Flex Mill

Shobhit Bhartiya, V. S. Y. Injeti, Chirag Mahimkar, Mat Bishop, Denis Hennessy, Matthew Enloe

Limiting Bainite Formation by Refinement in Nb-Microalloyed Hot-Rolled Sections

Yan Wang, Taylor Giddens, Bryan Williams, Douglas Stalheim, Matthew Enloe

Surface Characteristics of High-Manganese TRIP (Fe39Mn20Co20Cr15Si5Al1) Steel

Pranshul Varshney, Nilesh Kumar

Microstructural and Plastic Deformation Study of a Multi-Phase Advanced High-Strength Steel

Afm Monowar Hossain, Nilesh Kumar

ENERGY & UTILITIES

Energy & Utilities

An Assessment of Ultralow-NOx Combustion Technology for the Steel Industry

Justin Dzik

A Review of the Economic and Environmental Fundamentals of Selecting Heat Recovery for Combustion Systems in the Steel Industry

Dennis Quinn

ELECTRICAL APPLICATIONS

Electrical Applications: II

SDI Heartland Temper Mill Stand Motor and Drive Replacement

Thomas Richards, Gary Sinders, Neil Carpenter

Methodology for Fatigue Life Assessment of a Converter ID Fan Impeller Using the Finite Element Analysis Method: A Case Study

Andre Schiavon Perez Ortigosa

DIGITALIZATION APPLICATIONS

Analytics 4.0

Steel Continuous Annealing Line Simulation Improvements

Kelvin Erickson, Carlos J. Forjan, Logan Fulk, Vincent Johnson, Mike Leahy, Clayton Ohmes, Austin Smith

Real-Time Ordinary Differential Equation Solver in Digital Twin Environments

Hernan Castaneda, Javier Barreiro

How to Eliminate Missed Problems and False Alarms Using Machine Learning for Vibration Monitoring and Analysis

Boru Li, Andrew Lauden, Jonathan Davis, Klaus Stohl
Applications for the Digital Mill

Real Intelligence — A Novel Approach to EAF Optimization ............................................................. 1068
Mark Trapp, Jeremy Jones

Developing a Framework for a Process Digital Twin Using Unity 3D .................................................. 1076
Kyle Toth, John Moreland, Syed Khaleelullah, Aoya Sun, Luis Raygadas-Lara, Chenn Zhou, Bernard Chukwulebe, Charles Romberger, Alexander Samardzich, Nicolas Gregurich

Systematic Application of AI to Quality Optimization From Steelmaking to Galvanizing ................... 1082
Falk-Florian Henrich, Otmar Jannasch, Hossam Shafy, Jan Daldrop, Selim Arikan, Martin Rückl

Mill Management Systems

Development of ARMSS: Augmented Reality Maintenance and Safety System ....................................... 1090
John Moreland, Na Zhu, Myriam Changoluisa, Luis Raygadas-Lara, Garrett Page, Yury Krotov, Chenn Zhou

Software Innovations

Software-as-a-Service in the Metals Industry: Challenges, Requirements and Opportunities ............... 1096
Reinhold Leitner, Daniel Fuchshuber, Christoph Stangl

Applying Several AI Approaches to Improve the LF Steel Quality by Sulfide Capacity Estimation and Slag Chemical Composition Prediction ................................................................. 1104
María Luisa Argáez, Nelson Enrique Sánchez, Alex Alvarez

DIGITALIZATION APPLICATIONS/SENSORS

Digitalization Applications/Sensors

Innovative Surface Inspection System Deployment ............................................................................... 1116
Liwei Zhang, Armelle Perrichon, Luiz Alberto De Oliveira Martins, Brad Masters, Brian Feagan, Beth Isbell

Robotic Workstation for Safe Ladle Sliding Gate Maintenance ............................................................. 1128
Gianluca Maccani

Building a Scalable Intelligent System to Advise Predictive Maintenance Operations in a Steel Mill ...... 1133
Anshuman Sahu, Ravikant Chahar, Santiago Olivar, Ravi Balasubramanian, Atin Gupta, Hyungil Ahn

Transforming Metal Production by Maximizing Revenue Generation With Operational AI ................ 1141
Crick Waters, Beverly Klemme, Raj Talla, Prerna Jain, Nikunj Mehta

SENSORS

Sensors

The Next-Generation Surface Quality Management System .................................................................. 1152
Michael Hoenen, Greg Gutmann
An Assessment of State-of-the-Art Offgas Sensor Technology for Process Control in Steel Combustion Furnaces .......................................................................................................................... 1158
  Ken Grieshaber, Eric Huelson

How Artificial Intelligence Simplifies Automated Optical Surface Inspection Deployment and Operation in the Metals Industry .............................................................................................................. 1167
  Chris Miller, Jochen Koenig, Mark Cornell

PROJECT & CONSTRUCTION MANAGEMENT

Project & Construction Management

Planning for Success: Operational Readiness Planning and Change Management for Major Capital Projects ................................................................................................................................. 1173
  Neil Tannyan, Rifat Jabbar, Thomas Ruffner

Choosing an Electrical Supplier .................................................................................................................. 1179
  Thomas Richards, Gary Gepitulan

  Neil Tannyan, Matthew Marcus, George Granger, Nicole Sitler

Importance of Simulation and Modern Logistics in Project Management .................................................. 1201
  Robert Petty, Jagannathan Rajagopalan, Juha Suksi, Samu Katkanaho

MAINTENANCE & RELIABILITY

Maintenance & Reliability: I

Crane Girder Deformation Mapping Using Image Processing and Template Matching of Laser Scanner Point Cloud .............................................................................................................. 1211
  Sagar Deshpande, Michael Falk, Nathan Plooster

Maintenance & Reliability: II

Use of Insight Data Management Software to Improve Reliability at NLMK Indiana .............................. 1218
  James Gleason, Ehren Plew, Terry Black

Rolling Mill Bearing Lubrication Improvement Using Vacuum Dehydrators ........................................... 1223
  Scott Howard, Richard Trent, Aaron Hoeg

Maintenance & Reliability: III

Evaluation of Brush Holder Coatings for Resistance to Acid Fume Exposure ........................................... 1226
  Randy Herche, Nitin Kulkarni

Vastly Better Maintenance Results, Management Style and International Steel Group .......................... 1232
  Lyle Bufogle
LUBRICATION & HYDRAULICS

Lubrication & Hydraulics

Cost Savings and Advanced Equipment Availability While Utilizing Modern Lubrication Technology
Tim-Oliver Mattern, Dustin Greiner

Improving Roll Neck Bearing Lubrication
Mike Allega

Work Roll Bearing Grease Selection — Going Beyond the Data Sheets
Kuldeep Mistry, Mike Allega

REFRACTORY SYSTEMS

Refractory Systems

Corrosion Behavior of Tundish Refractories by Molten Steel and Tundish Flux
Tyler Richards, Ronald J. O'Malley, Jeffrey Smith, Todd Sander

Ladle Bottom Design for Optimized Steel Flow and Metallic Yield
Haysler Lima, Vladnilson Ramos, Douglas Galesi

Volume III

MATERIAL HANDLING/TRANSPORTATION & LOGISTICS

Material Handling/Transportation & Logistics

How to Improve the Quality of Inbound Scrap
Thomas Saccamozzone

The State of the Art in Magnetic Drum Separators for Scrap
Thomas Saccamozzone

CRANES

OHC Safe & Reliable Handling

Crane Rail Alignment Mapping Using Laser Scanner Point Cloud
Sagar Deshpande, Michael Falk, Nathan Plooster

VIRTUAL PROGRAM

Environmental

Gas Cleaning and Waste Heat Recovery Solutions for Integrated Steel Plants and Mini Mills — State-of-the-Art Technologies and Latest References
Alexander Fleischanderl, Thomas Steinpazer, Paul Trunner
Cokemaking & Ironmaking

Recovering Fines in Direct Reduction Plants

Ashton Hertrich, Liliana Arsene, Selena Tiburzio, Luca Tommasi

1308

Clean Steel for New Environmental Opportunities: A Very Important Role for the Steel Industry in the New Industrialized Era

Giorgio G. Parodi, Edward Canepa

1318

Assessment of a Methodology to Measure Carbon Footprint and Support Decision-Making Process in a Company’s Supply Chain

Gustavo Gilberti, Edenilson Silva Filho, Thais Carreira

1324

New EAF Dust Treatment Process for Co-Production of Metallic Zinc and Calcium-Ferrite

Shunsuke Koide, Hitosi Mizuno, Kazuyoshi Yamaguchi, Fumio Tanno, Tetsuya Nagasaka

1335

Development and Successful Evaluation of an Atmosphere-Controlled Furnace for Direct Reduction Feedstock Studies

Michael Nispel, Bryan Souchon, Felix Firsbach

1345

Hisarna: Benefits of a New Developed Smelting-Reduction Option for Ironmaking

J. L. T. Hage, Christiaan Zeilstra, Johan Van Boggelen, H. K. A. Meijer, J. Van Der Stel, T. Peeters

1356

Modernization of DRI Shaft Furnaces to Improve Performance and Product Quality

Yakov Gordon, N. A. Spirin

1368

Blast Furnace Data Validation Using Deep Learning as an Enabler for Autonomous Blast Furnace

Cedric Schockaert, Fabrice Hansen, Franck Giroldini, Alexander Schmitz

1378

Maintenance for Ironmaking Becomes Smart: The Power of Digitizing, Sharing and Linking Valuable, Empirical Knowledge

Stephan Weyer, Fabrice Hansen, Yves Reuter, Alexander Schmitz

1390

Top Gas Recycling Revisited to Reduce Blast Furnace CO2 Emissions

Mitren Sukhram, Kyle Lefebvre, Nicholas Aubry, Ian Cameron, Ben Ellis, Xinliang Liu, Tom Honeyands

1400

Blast Furnace Energy Balance — A Sensible Heat Approach

John Busser

1413

Blast Furnace Flame Temperature Calculation Improvements

John Busser

1425

Coal Rheology — The Effect of Rank and Sample Preparation on Test Results

Ted Todoschuk, Louis Giroux

1439

Effective Utilization Techniques for Coal Having High Maximum Fluidity Based on Unique Permeation Distance Evaluation

Yusuke Dohi, Kiyoshi Fukada, Takashi Matsui, Tetsuya Yamamoto, Mikiya Nagayama, Daisuke Igawa, Issui Akishika, Hironuki Sumi, Izumi Shimoyama

1446

The Influence of Coke Reactivity on the Raceway Size — A Case Study

Markus Bösenhofer, Eva-Maria Wartha, Franz Hauzenberger, Christoph Feilmayr, Hugo Stocker, J. Rieger, Magdalena Schatzl, Michael Harasek

1460
Utilization of 6- to 20-mm Waste Metallic Scrap as a Charge Material and Reduction of Carbon Rate and HM Silicon at E Blast Furnace of Tata Steel Ltd. Jamshedpur .................................................. 1470
Biswajit Seal, Subal Kumar Saha, Dushyant Kumar, Mantu Patra, Mayank Tiwari

30+ Year Campaign of IJmuiden Blast Furnace No. 6 .......................................................... 1479
Frank Kerkhoven, J. Stuurwold, G. Tijhuis, B. Nugteren, Reinoud Van Laar

**Steelmaking**

Using Mathematical Modeling to Develop the Indexes Indicating Dependency of Arc Stability in the EAF on Charge Material Quality and Electrode Regulation Effectiveness ........................................... 1490
Bipin Richharia, T. Nagarajan, Juan Ramon Fernandez, Neeraj Shukla

Comprehensive Process Optimization for Electric Steelmaking Route ..................................... 1498
Richard Stadlmayr, Andreas Rohrhofer, Franz Hartl

Dolime-Based EAF Hot Repair Material — Successful Product Improvements ...................... 1506
Felix Firsbach, Guillaume Bruel, Ian Houldsworth, Jonathan Guest, Souliyann Chunlamani

Optimization of Electrode Consumption in EAF for Different Operating Conditions ............. 1517
Bipin Richharia, T. Nagarajan, Juan Ramon Fernandez, Manendra Sharma

Value Creation of Dolime Compared to MgO Alternatives for EAF Application ................... 1528
Eric Perrin, Felix Firsbach, Michael Nispel, John Beatty, William Johnson

State-of-the-Art Converter Technology: Proven Features for Longest BOF Lifetime ................ 1541
Günther Staudinger, Michael Skorianz, Joachim Lehner

Analysis of Heat Loss in Oxygen Steelmaking ........................................................................ 1553

Functionalization of Supersonic Oxygen Lance for EAF ......................................................... 1560
Masashi Yamaguchi, Yasuyuki Yamamoto, Yoshiyuki Hagihara

**Refining & Casting**

Basic Actions to Prevent Continuous Casting Defects of Billets ........................................... 1572
José Bacalhau, Jose Bolota, Danilo Guzela, Marcos Nogueira

Inclusion Shape Control Through Ca Treatment .................................................................... 1585
Keyan Miao, Muhammad Nabeel, Neslihan Dogan, Stanley Sun

Study on Production Technology of Clean Steel in Phase II of Shougang Jingtang United Iron and Steel Co. ................................................................................................................ 1593

Influence of Mold Powder Slag Composition on Formation of Oxide Particles in Steel ........... 1600
Junya Ito, Yukimasa Iwamoto, Jim Gilmore, Masanori Okada

Safety-Certified Positioning and Anti-Collision System at Steel Mill Cranes ......................... 1610
Thomas Brandenburger, Peter Haarhoff
Investigation on Flying Tundish Change and Separation Plate Using Micro-X-Ray Fluorescence at ArcelorMittal Dofasco's No. 1 Continuous Caster ................................................................. 1616
  Jackie Leung, Manh Kha Trinh

Digital Optimization of Refractory Maintenance ..................................................................................................................... 1625
  Nikolaus Mutsam, Franz Pernkopf, Gregor Lammer

In-Plant Observations and Thermomechanical Modeling of Different Vessel Types Applying an Insulation Layer ................................................................. 1635
  Lionel Rebouillat, Shengli Jin

Gas Bubble Digital Data Generation by Image Analysis Using Reduced-Scale Water Modeling of a Slab Continuous Caster Mold .......................................................... 1642
  Soumitra Kumar Dinda, Amiy Srivastava, Kinnor Chattopadhyay, Joydeep Sengupta

A Comparison Study on the Characterization of Bubbles Formed in a Ladle and a Continuous Casting Mold During Gas Injection Using Advanced Imaging Techniques ........................................... 1655
  Amiy Srivastava, Soumitra Kumar Dinda, Kinnor Chattopadhyay, Joydeep Sengupta

Use of Discrete-Event Simulation for Production Expansion Planning at NLMK Indiana LLC ................................................................. 1667
  Emily Valley, Russell Sindrey, Randal Beardsley, Steve Ryan

History and Latest Technology of Castables for Steel Ladles of Japanese Integrated Steel Mills ................................................................. 1679
  Masafumi Nishimura, Koji Asakawa

Rolling & Processing

Automatic Pilot For Strip Processing Lines ................................................................................................................................. 1694
  Etienne Menigault, Philippe Rocabois, Maxime Monnoyer, Arnaud Ollagnier, Aldo Fiorini, Stefano Pantarotto, Alessandro Ferraiuolo

Cutting-Edge Process Technologies to Enhance Electrical Steel Performances ................................................................................................. 1704
  Camille Moukarzel

Development of Electrical Discharge Coating for Extended Textured Roll Campaigns ................................................................................................. 1712
  Chris Childs, G. Evans, T. Lowbridge

Design and Application of an Optimum Roughing Mill Backup Roll Contour in a Hot Strip Mill ................................................................. 1718
  Mustafa Saygili, Özkan Özkan

Heat Transfer Modeling and Adjustment From Radar Measurements in Reheating Steel Furnaces ................................................................. 1725
  Patrik Ottosson, Fredrik Blomqvist, Daniel Andersson, Tomas Ekman

A Machine-Learning Approach for Steel Grade Detection in Hot Rolling Mills ................................................................................................. 1742
  Pedro Emilio Gazola, H. S. O. Dos Santos, M. Daroit, A. Locatelli

Key Challenges for Efficient Descaling ............................................................................................................................................... 1747
  John Hinton, J. Lee

Hot Rolling Coil Technology Development for Pipes Intended for Extraction and Transportation of Petroleum Products ................................................................. 1758
  Aleksei Ogoltsov, Artem Mitrofanov

Microstructure and Property Investigations for Heavy-Gauge Line Pipe Development ................................................................................................. 1770
  Michael Gaudet, Jing Su, Muhammad Rashid, Gail Smith, Kendal Dunnett, Muhammad Arafin
Steel Rolling Mill Crop Cobble Shear Operation Improvement — Time Tail Cut .................................................. 1781
Gary Ng, Shawn Caljouw

Full Hydraulic Solution — The Advanced Fourth-Generation Pair Cross Mill .................................................. 1790
Longze He, Akira Sako, Jiro Hasai, Takao Owada

**Metallurgy**

Investigation on Softening/Hardening Mechanisms Occurring During the Hot Rolling Process by Means of Advanced, Self-Training Virtual Smart Sensors .................................................. 1796
Alessandro Ferraiuolo

IR Temperature Measurement to Monitor Induction Hardening Processes.................................................. 1809
Daniel Schuefian, Janelle Coponen

Wet Flash Cooling: A Flexible and High-Performance Quenching Technology for Gen3 AHSS .............. 1812
Stephane Mehrain, Sébastien Lemaire

Mathematical Modeling of Residence Time Distribution in a Twin-Strand Slab Caster Tundish ............ 1818
Donghui Li, Fernando Guerra, Chad Cathcart, Kinnor Chattopadhyay

Investigation of Optimal Continuous Casting Condition for Superior Steel Cleanliness ...................... 1829
Bikram Konar, Jyoti Saroop, Shaojie Chen

Characteristics and Thermodynamics of Nozzle Clogging in Ti-Stabilized Ultra-Pure Stainless Steels ................................................................. 1841
Xuefeng Bai, Zirong Zhao, Xiaoshuai Hao, Yanhui Sun

A Metallurgy-Based Real-Time Quality Certification System ................................................................. 1853
Maxime Monnoyer, Raphaël Biland, Etienne Menigault, Denys Seguret

Development of Quantitative Indices and Machine Learning-Based Predictive Models for SEN Clogging ...................................................................................... 1860
Ruibin Wang, Heng Li, Fernando Guerra, Chad Cathcart, Kinnor Chattopadhyay

**VIRTUAL PROGRAM**

**Digitalization**

Q3-Premium — DIGI&MET Solution for Decision Intelligence in Quality Management ...................... 1870
Luca Cestari, Gina Verbanac, Gabriel Madotto, Marco Ometto

**VIRTUAL PROGRAM**

Artificial Intelligence and Data-Driven Modeling in Ironmaking — Potential and Limitations .......... 1881
Dieter Bettinger, Harald Frischek, Adnan Husakovic, Petra Krahwinkler, Martin Schaler, Sonja Straszer

Mastering Fully Automated Steelmaking .................................................................................................. 1894
Richard Stadlmayr, Christoph Stangl

Shooter 4.0 — A Prototype for Intelligent and Autonomous Gunning Maintenance .......................... 1904
Nikolaus Mutsam, Gregor Lammer, Ronald Lanzenberger, Douglas Beish

**Author Index**