



**Proceedings of the
Iron & Steel Technology Conference
Volume I**

**29 June–1 July 2021
Nashville, Tenn.
U.S.A.**



Ronald E. Ashburn, *Publisher*

Amanda L. Blyth, *Publications Manager*

Jennifer M. Emling, *Technical Editor*

Emily C. Williams, *Technical Editor*

Carolyn Trobaugh, *Graphic Designer*

A Publication of the Association for Iron & Steel Technology

AISTech 2021
Iron & Steel Technology Conference Proceedings
Volume I

Copyright © 2021 by Association for Iron & Steel Technology or the authoring company(ies).
Contact AIST for specific information on reprinting or repurposing any part of this publication.

All rights reserved.
Printed by Curran Associates in the U.S.A.
www.proceedings.com/59439.html

ISBN: 978-1-935117-93-3 (Print)
ISBN: 978-1-7138-3513-4 (CD-ROM)
ISSN: 1551-6997

Association for Iron & Steel Technology
186 Thorn Hill Road
Warrendale, PA 15086-7528
U.S.A.
Phone: +1.724.814.3000
Fax: +1.724.814.3001
memberservices@aist.org
AIST.org

The Association for Iron & Steel Technology is not responsible for statements or opinions
expressed in this publication.

In the development, submittal and presentation of material for publication for any of the Association for Iron & Steel Technology's (AIST's) media, AIST seeks to maintain the highest standard in its service to the industry. AIST expects its members, authors and presenters to adhere to these standards within any AIST function or forum. Plagiarism within submitted work will not be tolerated. Any responsibility for the thorough investigation of work submitted for publication in AIST media lies with the author or the author's employer prior to said submission. AIST shall not be liable for any outcome related to claims of plagiarism.

Papers and presentations delivered at AIST-sponsored forums are intended to be technical in nature, with solutions supported by verifiable data. Commercially motivated commentary or endorsement of specific brands or companies is not acceptable. Each paper/presentation will be peer-reviewed by forum organizers to ensure compliance with this policy. If the paper/presentation is deemed to be in violation, the author/presenter will be notified by the forum organizer(s) and given the opportunity to revise the content or to withdraw the paper/presentation. To preserve and protect the interests of AIST, forum organizers will have the authority and the responsibility to stop any paper/presentation they determine to be in violation of this policy.

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
<i>Justin Heffron, Chenhao Zhang, John Moreland, Kyle Toth, Angela Hiller, Jeff Mitchell, Robbie Britton, Stephen Borzych, Chenn Zhou</i>	
Smart Safety Guard — Improving Safety Through Real-Time People Localization	8
<i>Nicolas Schlessler, Fabrice Hansen, D. Jakubowski, Yves Reuter</i>	

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
<i>Simon Shipp</i>	
Managing Heat Stress-Related Injuries and Illness in the Iron and Steel Industry	33
<i>Rupkatha Bardhan, Melina Eaker, William Ryan Gaskins, Jacob Crissup</i>	
A Holistic Approach Toward the Next Level of Safe EAF Operation	41
<i>Danny Schreiber, Andreas Volkert, Ralf Schweikle, Sven Fuchs, Patrick Hansert, Cara Riedel</i>	

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
<i>Christopher Machut</i>	
Material Flow How Concept for Steel Plants and Warehouses	50
<i>Juha Suksi, Samu Katkanaho, Jagannathan Rajagopalan</i>	

ENVIRONMENTAL

Emissions Control I

Case Study: System Modifications Enhance Overall Ventilation Systems	65
<i>Ray Tedford</i>	
Modern Blast Furnace Top Gas Cleaning: Wet Separation Improvements at U. S. Steel – Great Lakes Works B2 Blast Furnace	76
<i>Jean-Luc Kuffer, Jim Quick, Christian Davidi</i>	

Environment Defines Productivity: Emission Control System Modifications Using Fluid Dynamic Study of Building Ventilation at Sinobras Meltshop, Brazil	86
<i>Jim Belous, Milton Lima</i>	

Emissions Control II

How U.S. Steelmaking Became a Green Industry and What Lies Ahead	97
<i>Francesco Memoli</i>	
Review of Centrifugal Fan Design Decisions Over the Past 25 Years of Operation	129
<i>Sean Graham, Steve Back, Mike Schlemmer, Dan Banyay</i>	

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
<i>Michael Alter</i>	
Machine Learning for Blast Furnace Productivity Improvement at Jindal Steel and Power Angul	147
<i>Anil Gandhi, Ritesh Mishra, Aniruddha Fadnis, Richa Jaiswal, Sambit Mishra, Amitava Sircar</i>	
Numerical Study of Heat Transfer for Microwave-Assisted Reduction of Hematite	158
<i>Prasenjit Singha, Sunil Yadav, Soumya Ranjan Mohanty, Ajay Kumar Shukla</i>	

Blast Furnace Injection & Stove Technologies

Investigation of High-Rate and Pre-Heated Natural Gas Injection in the Blast Furnace	168
<i>Samuel Nielson, Tyamo Okosun, John D'Alessio, Shamik Ray, Mitchell Klaas, Chenn Zhou</i>	
Techno-Commercial Reasons to Invest in Hot Blast Stoves	180
<i>Mark Geach, John Croot</i>	
Blast Furnace Operation Improvement by Forming Uniform Circular Distribution of Raceway's Thermal Mode	184
<i>Yuriy Semenov, Viktor Horupakha, Evgen Shumelchik, Michael Alter</i>	

Blast Furnace Relines, Repairs & Restarts

Ironmaking in Russia	193
<i>Yakov Gordon, Dmitriy Tikhonov, Dina Vorsina, Alexey Tretyak</i>	

Raw Materials

Addition of Scrap and DRI/HBI to the Blast Furnace — Technology to Overcome Top Temperature Limits and Reduce Greenhouse Gas Emissions	205
<i>Ian Cameron, Don Tu, Mitren Sukhram, Janice Bolen, Jennifer Woloshyn</i>	
Cold-Bonded Briquette Testing Methodology and Standards Used for Traditional Furnace Feedstocks	217
<i>Mac Steele, Mark T. Ford</i>	

DIRECT REDUCED IRON

DRI Plant Operations & Digital

Investigation of Carbon Deposition During Natural Gas and Oxygen Injection for the Direct Reduction Ironmaking Process.....	227
<i>Tyamo Okosun, Yu Wang, Qurram Syed, Elaine Chen, Rui Liu, Cesar Velazquez, Joel Carmona, Chenn Zhou</i>	
Rising and Failure of Gas-Based Direct Reduction Processes	237
<i>Yakov Gordon</i>	

Hydrogen-Based DRI

Hydrogen-Based DRI EAF Steelmaking — Fact or Fiction?.....	249
<i>Sara Hornby</i>	
MIDREX H2 — The Road to CO ₂ -Free Iron and Steelmaking.....	262
<i>Robert Millner, Johannes Rothberger, Barbara Rammer, Christian Boehm, Wolfgang Sterrer, Hanspeter Ofner, Vincent Chevrier</i>	
Searching New Horizons: The Hydrogen Revolution in Steelmaking	274
<i>Paolo Argenta, Francesco Memoli</i>	

ELECTRIC STEELMAKING

EAF Energy

Dynamic EAF Energy and Material Balance Model for On-Line Process Optimization.....	282
<i>Sunday Abraham, Yufeng Wang, Randy Petty, Tim Sprague, Tony Franks, Eric Brown</i>	
Implementation of the Tilttable Sidewall Burner at Nucor Steel Tuscaloosa Inc.: Dynamically Adjustable Burner Angle to Optimize Scrap Melting and Reduce Refractory Wear	297
<i>Justin Novotny, Ryan Junkin, Michael Mayhall, Jake Franks, Phil Baker, Patrick Hansert, Fatih Goekce</i>	
Application of JetBurner Technology for a Small-Sized EAF	307
<i>Juergen Jung, Taras Gabriel, Adam Partyka, Martin Pavliš</i>	

EAF Performance I

Bath Level Management in the Consteel DC Electric Arc Furnace	317
<i>Pat Quiney, Kaleb Fitch, Paul Turner, Leonard Meads</i>	
The EAF for Integrated Plants.....	330
<i>Jens Apfel</i>	

EAF Performance II

Numerical Investigation of DC Electric Arc Behavior Under the Consideration of Electrode Movement.....	339
<i>Yuchao Chen, Yu Wang, Armin Silaen, Chenn Zhou</i>	

OXYGEN STEELMAKING

Improving Performance & Control

Novel Method for Stirring BOF Melts in Conjunction With Slag Splashing	348
<i>Anand Makwana, Anup Sane, Xiaoyi He, Gregory Buragino</i>	
Installation of Vaicon Slag Stopper at U. S. Steel – Great Lakes Works	357
<i>Ernesto Serrano, Gerald Wimmer, David Runner, Yun Li, Denis Vaillancourt, Michael Maringer</i>	
Ladle Hot Spot Detection — A Novel and Robust Approach to Eliminate False Positives in Infrared Thermal Image Analysis	366
<i>Miguel Simiand, Javier Barreiro, Ignacio Salinas</i>	

Operational Practices & Issues

Spray-Cooled BOF Hoods at U. S. Steel – Gary Works: 28 Years	373
<i>Louis Valentas, Troy Ward</i>	
Revamp of BOF Converters at AK Steel–Middletown Works Using Vaicon Link 2.0 Converter Vessel Suspension System	383
<i>Steve Torok, Gerald Wimmer, Georg Unterrainer, Denis Vaillancourt</i>	
Increased Safety and Performance of BOF Relining at Ternium Brasil	392
<i>Leonardo Demuner, Bernhard Voraberger, Willian Correa, Gerald Wimmer</i>	

SPECIALTY ALLOY & FOUNDRY

Specialty Alloy & Foundry

Effect of RE Master Alloys on AISI 1030 Steel	400
<i>Robert Tuttle</i>	

LADLE & SECONDARY REFINING

Ladle & Secondary Refining: I

Analysis of Inclusion Clusters Using Machine-Learning Tools	414
<i>Mohammad Abdulsalam, M. Jacobs, Bryan Webler</i>	
Smart Ladle: AI-Based Tool for Optimizing Casting Temperature	428
<i>Nicholas Walla, Zhankun Luo, Bin Chenn, Yury Krotov, Chenn Zhou</i>	

Ladle & Secondary Refining: II

The Effects of Non-Metallic Inclusions on Charpy V-Notch Toughness	436
<i>Sunday Abraham, Rick Bodnar, Eric Lynch, Yufeng Wang</i>	
A Comparison of the Dynamics, Mixing Efficiency and Ladle Wall Wear in Gas-Stirred Ladles	448
<i>Pavan Kumar Shivaram, Markus Gruber, Tyler Spudic</i>	

CONTINUOUS CASTING

Casting Technologies & Process Improvements

High-Throughput Casting Technology — Challenges and Solutions	459
<i>Juergen Mueller, Christian Froehling, Frank Seuffert</i>	
A Fiber-Optic-Distributed Temperature Mapping Technique to Characterize Shell Solidification in Peritectic-Grade Steels	465
<i>Damilola Balogun, Muhammad Roman, Laura Bartlett, Ronald J. O'Malley, Rex Gerald, Jie Huang</i>	
Digital Technologies for Continuous Casting	474
<i>Gianluca Maccani, Vittore Girardin</i>	
Design and Evaluation of a Lab Size Vacuum Sampling Method for Simulating the Twin-Roll Strip Casting Process.....	477
<i>Yizhou Du, Ronald J. O'Malley, Mario Buchely, Mingzhi Xu</i>	

Mold Behavior

A Potential Application for Utilizing Adaptive Mesh Refinement in a Continuous Caster Simulation	485
<i>Matthew Moore, John Resa, Xiang Zhou, Haibo Ma, Armin Silaen, Chenn Zhou</i>	
Modeling of Air-Mist Spray in Continuous Casting of Steel	497
<i>Vitalis Ebuka Anisiuba, Haibo Ma, Armin Silaen, Chenn Zhou</i>	

New Installations & Modernizations

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

CONTINUOUS CASTING/METALLURGY — STEELMAKING & CASTING

Continuous Casting/Metallurgy — Steelmaking & Casting

Reduction of Transverse Corner Cracks During Continuous Casting of Slabs	517
<i>Yufeng Wang, Miles Haberkorn, Dallas Brown, Sunday Abraham, Randy Petty</i>	
Hot Ductility Behavior of V-N Microalloyed Steels	528
<i>Madhuri Varadarajan, Laura Bartlett, Ronald J. O'Malley, Simon Lekakh, Mario Buchely</i>	
Reducing Corner Cracks With a New Strategy for Secondary Cooling	540
<i>Paul Pennerstorfer, Andreas Mittermair, Se-Ho Lim, Won-jae Cho</i>	

HOT SHEET ROLLING

Emerging Technologies

A Thermomechanical-Microstructural Model of a Hot Strip Mill	547
<i>Eugene Nikitenko, Susan Farjami</i>	

Inspection of Rolled Heavy Plate by 3D Inspection	555
<i>Dominik Recker, Greg Gutmann</i>	
Revolutionary Endless Strip Production up to 20 mm — Precise and Uniform HSLA Steel	564
<i>K. Baumgartner, T. Lengauer, S. Grosseiber, Andreas Jungbauer</i>	
Power Cooling — Advanced Strip Cooling Technology for Hot Strip Mills for Maximum Metallurgical Flexibility, High Cooling Rates and for Saving of Alloying Elements	571
<i>Lukas Pichler, Konrad Krimpelstaetter, Ruediger Doell, Klaus Weinzierl</i>	
Measuring Flatness of Rolled Strips Under Tension in Hot Rolling Mills	582
<i>Frank Gorgels, Olaf Jepsen, Patrick Siemann, Mark Zipf</i>	

New Capabilities & Product Quality

Descaling of Medium C and High Si, Mn Steels	590
<i>Richard Osei, Simon Lekakh, Ronald J. O'Malley, Lesli Peterson, Oldair Sasso</i>	
Prediction of Damage During Different Hot Rolling Schedules of Medium-Carbon V-Microalloyed Steel	602
<i>Shouvik Ganguly, Mario Buchely, F. Okanmisope, K. Chandrashekhara, Simon Lekakh, Ronald J. O'Malley, J. Heerema</i>	
Application of Oxygen-Enriched Combustion in an Industrial Reheating Furnace Using CFD	612
<i>Bethany Worl, Francisco Martinez, Armin Silaen, Kurt Johnson, Larry Fabina, Kelly Tian, Joe Maiolo, Chenn Zhou</i>	
The Widest ESP Line for U. S. Steel — Full Digitalization Possibilities	621
<i>Andreas Jungbauer, Klaus Jax, Roman Winkler, M. Ringhofer, Michael Weinzinger, Klaus Frauenhuber, Adnan Cosic, B. Voglmayr, A. Haschke, A. Maierhofer</i>	
On-Line Monitoring System to Detect Anomaly of Rolls in Rolling Mills	632
<i>Yuki Okano, Hiroyuki Imanari, Kazuyuki Maruyama, Yukihiro Yamasaki</i>	

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	642
<i>Mark Zipf</i>	
Fine-Scale Details Within the Roll Clusters of 20-High/Sendzimir Mills, Part 2: Micro-Dynamic Interactions	665
<i>Mark Zipf</i>	
Lightweight Work Roll Flattening Model for Severe Rolling Conditions	682
<i>Brian Braho, Robert Paul Schaeffer</i>	
Innovative Roll Profile Design for Thin-Strip Cold Rolling Mills	691
<i>Navneet Singh, Satish Kumar Tripathi, Manish Kumar, Amit Sharma, Vidyadhar Kelkar</i>	

Cold Sheet Rolling: II

Transverse Flux Induction Heating Technology and High Flux Inductors.....	702
<i>Emmanuel Patard, Tony Kezer, Kevin Bertermann</i>	
Key Technologies Supporting the Production of NGO Electrical Steels	709
<i>Toru Nakayama, Konrad Krimpelstaetter</i>	
Cold Rolling Mill Technologies for Electrical Steel	722
<i>Akihiro Yamamoto</i>	

GALVANIZING

Galvanizing

New High-Performance X-Ray Coating Weight Gauge for Metals	730
<i>Jean-Jacques Florent, Jan Gaudaen, Francois Legrand, Roland Gouel</i>	
Physical Modeling for Product Development and Performance Optimization in Hot Dip Galvanizing Lines.....	743
<i>Ben Reed, Luis Felipe Simoes, Dennis McHugh, C. Isaac Garcia</i>	

PLATE ROLLING

Plate Rolling

Advanced Cooling Technology to Improve High-Strength Plate-Steckel Mill Steel Production.....	752
<i>Ian Robinson, Joachim Kilato, Dengqi Bai, Chase Rawlinson</i>	
Evaluation of Mechanical Behavior Shifting of API 5L X70M Skelp Through Accelerated Cooling and Spiral Forming Processes.....	762
<i>Qiulin Yu, Jacob Lewis, Matt Montgomery, Pn Mahida, Ashish Singh</i>	
Production of X70 Discrete Plate Using Mulpic.....	774
<i>Dengqi Bai, Chase Rawlinson, Kenneth Hodges, Ian Robinson</i>	
Modernization and Customization of a Copper Plate Mill Descale System	786
<i>Steve Demar</i>	
AI Application to Front-End Bending Prediction.....	792
<i>Marcelo Saparrat, Fernando Monti, José Ibarra</i>	

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
<i>Jerome Dapore, D. R. Parra Solís, H. Santoyo Avilés, I. Chávez Mendoza, J. J. Cerón Gonzalez</i>	
Material Flow How® Concept for Wire Rod Coils.....	812
<i>Juha Suksi, Jagannathan Rajagopalan, Samu Katkanaho</i>	

METALLURGY — STEELMAKING & CASTING

Metallurgy — Steelmaking & Casting

Improvement of Centerline Segregation at United States Steel Corporation's Gary Works No. 2 C Line Continuous Caster	819
<i>Ernesto Serrano, S. McCann, William Schlichting, M. Keel, C. Paynes, M. Liedtke, Thinius Natarajan, B. Flanigan, C. C. Tomazin, M. Knights, M. Fornasier</i>	
100% In-Process Compositional Testing Using X-Ray Fluorescence	827
<i>Alex Thurston</i>	
Prediction of Inclusion GSV: A Quality Control Tool for Inclusion SEM Analysis	834
<i>Mohammad Abdulsalam, Bryan Webler</i>	
Data-Driven Study of Desulfurization During Ladle Treatment and Its Impact on Steel Cleanliness	845
<i>Stephano Piva, P. Chris Pistorius</i>	
Computational Studies and Optimization of Inclusion Removal in a Steel Ladle	858
<i>Xipeng Guo, Joel Godinez, Nicholas Walla, Armin Silaen, Helmut Oltmann, Vivek Thapliyal, Abhishek Bhansali, Eugene Pretorius, Chenn Zhou</i>	

METALLURGY — PROCESSING, PRODUCTS & APPLICATIONS

Developments in Steel Processing

Non-Linear Bending Control for Temper Mills	874
<i>Brian Braho, Robert Paul Schaeffer</i>	
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
<i>Chirag Mahimkar, Venkata Natarajan, V. S. Y. Injeti, Jay Martin, Denis Hennessy, Amar De</i>	

Physical Metallurgy of Steels I

Process and Physical Metallurgical Developments for High-Performance Niobium-Containing Pressure Vessel Steel Plates	896
<i>Steven Jansto</i>	
Development of ASTM A709-50WF Heavy Plate for Fracture Critical Bridge Applications	909
<i>Dengqi Bai, Yufeng Wang, Liz Peterson, Chase Rawlinson, Chris Amsden</i>	
Effect of Through-Thickness Microstructural Homogeneity on Fatigue Performance of Structural Steels in Air and Hydrogen Environments	924
<i>Douglas Stalheim, Andrew Slifka, Enrico Lucon, Pello Uranga, Dong-hoon Kang</i>	
Yield Stress in Ferritic Steels Influenced by Grain Boundary Walls	935
<i>Thomas L. Altshuler</i>	
Effects of Steel Composition and Reheating Temperature on Prior Austenite Grain Size	949
<i>Dengqi Bai, Hanok Tekle, Jacob Mineart, Eric Lynch</i>	

Physical Metallurgy of Steels II

Approach to Successful Production of Very-Low-Carbon High-Strength Galvanized Dual-Phase Steels Through a CSP Flex Mill	964
<i>Shobhit Bhartiya, V. S. Y. Injeti, Chirag Mahimkar, Mat Bishop, Denis Hennessy, Matthew Enloe, Amar De</i>	
Limiting Bainite Formation by Refinement in Nb-Microalloyed Hot-Rolled Sections.....	977
<i>Yan Wang, Taylor Giddens, Bryan Williams, Douglas Stalheim, Matthew Enloe</i>	
Surface Characteristics of High-Manganese TRIP (Fe39Mn20Co20Cr15Si5Al1) Steel	986
<i>Pranshul Varshney, Nilesch Kumar</i>	
Microstructural and Plastic Deformation Study of a Multi-Phase Advanced High-Strength Steel	994
<i>Afm Monowar Hossain, Nilesch Kumar</i>	

ENERGY & UTILITIES

Energy & Utilities

An Assessment of Ultralow-NOx Combustion Technology for the Steel Industry.....	1002
<i>Justin Dzik</i>	
A Review of the Economic and Environmental Fundamentals of Selecting Heat Recovery for Combustion Systems in the Steel Industry	1010
<i>Dennis Quinn</i>	

ELECTRICAL APPLICATIONS

Electrical Applications: II

SDI Heartland Temper Mill Stand Motor and Drive Replacement	1020
<i>Thomas Richards, Gary Sindors, Neil Carpenter</i>	
Methodology for Fatigue Life Assessment of a Converter ID Fan Impeller Using the Finite Element Analysis Method: A Case Study.....	1028
<i>Andre Schiavon Perez Ortigosa</i>	

DIGITALIZATION APPLICATIONS

Analytics 4.0

Steel Continuous Annealing Line Simulation Improvements	1037
<i>Kelvin Erickson, Carlos J. Forjan, Logan Fulk, Vincent Johnson, Mike Leahy, Clayton Ohmes, Austin Smith</i>	
Real-Time Ordinary Differential Equation Solver in Digital Twin Environments.....	1045
<i>Hernan Castaneda, Javier Barreiro</i>	
How to Eliminate Missed Problems and False Alarms Using Machine Learning for Vibration Monitoring and Analysis	1054
<i>Borui Li, Andrew Lauden, Jonathan Davis, Klaus Stohl</i>	

Applications for the Digital Mill

Real Intelligence — A Novel Approach to EAF Optimization	1068
<i>Mark Trapp, Jeremy Jones</i>	
Developing a Framework for a Process Digital Twin Using Unity 3D	1076
<i>Kyle Toth, John Moreland, Syed Khaleelullah, Aoya Sun, Luis Raygadas-Lara, Chenn Zhou, Bernard Chukwulebe, Charles Romberger, Alexander Samardzich, Nicolas Gregurich</i>	
Systematic Application of AI to Quality Optimization From Steelmaking to Galvanizing	1082
<i>Falk-Florian Henrich, Otmar Jannasch, Hossam Shafy, Jan Daldrop, Selim Arian, Martin Rückl</i>	

Mill Management Systems

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

Software Innovations

Software-as-a-Service in the Metals Industry: Challenges, Requirements and Opportunities	1096
<i>Reinhold Leitner, Daniel Fuchshuber, Christoph Stangl</i>	
Applying Several AI Approaches to Improve the LF Steel Quality by Sulfide Capacity Estimation and Slag Chemical Composition Prediction	1104
<i>María Luisa Argáez, Nelson Enrique Sánchez, Alex Alvarez</i>	

DIGITALIZATION APPLICATIONS/SENSORS

Digitalization Applications/Sensors

Innovative Surface Inspection System Deployment	1116
<i>Liwei Zhang, Armelle Perrichon, Luiz Alberto De Oliveira Martins, Brad Masters, Brian Feagan, Beth Isbell</i>	
Robotic Workstation for Safe Ladle Sliding Gate Maintenance.....	1128
<i>Gianluca Maccani</i>	
Building a Scalable Intelligent System to Advise Predictive Maintenance Operations in a Steel Mill	1133
<i>Anshuman Sahu, Ravikant Chahar, Santiago Olivar, Ravi Balasubramanian, Atin Gupta, Hyungil Ahn</i>	
Transforming Metal Production by Maximizing Revenue Generation With Operational AI.....	1141
<i>Crick Waters, Beverly Klemme, Raj Talla, Prerna Jain, Nikunj Mehta</i>	

SENSORS

Sensors

The Next-Generation Surface Quality Management System.....	1152
<i>Michael Hoenen, Greg Gutmann</i>	

An Assessment of State-of-the-Art Offgas Sensor Technology for Process Control in Steel Combustion Furnaces	1158
<i>Ken Grieshaber, Eric Huelson</i>	

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

PROJECT & CONSTRUCTION MANAGEMENT

Project & Construction Management

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

Choosing an Electrical Supplier	1179
<i>Thomas Richards, Gary Gepitulan</i>	

Best Practices for Conducting Factory Acceptance Tests on Major Capital Projects	1195
<i>Neil Tannyan, Matthew Marcus, George Granger, Nicole Sitler</i>	

Importance of Simulation and Modern Logistics in Project Management	1201
<i>Robert Petty, Jagannathan Rajagopalan, Juha Suksi, Samu Katkanaho</i>	

MAINTENANCE & RELIABILITY

Maintenance & Reliability: I

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

Maintenance & Reliability: II

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

Rolling Mill Bearing Lubrication Improvement Using Vacuum Dehydrators	1223
<i>Scott Howard, Richard Trent, Aaron Hoeg</i>	

Maintenance & Reliability: III

Evaluation of Brush Holder Coatings for Resistance to Acid Fume Exposure	1226
<i>Randy Herche, Nitin Kulkarni</i>	

Vastly Better Maintenance Results, Management Style and International Steel Group	1232
<i>Lyle Bufogle</i>	

LUBRICATION & HYDRAULICS

Lubrication & Hydraulics

Cost Savings and Advanced Equipment Availability While Utilizing Modern Lubrication Technology	1241
<i>Tim-Oliver Mattern,Dustin Greiner</i>	
Improving Roll Neck Bearing Lubrication	1245
<i>Mike Allega</i>	
Work Roll Bearing Grease Selection — Going Beyond the Data Sheets	1249
<i>Kuldeep Mistry,Mike Allega</i>	

REFRACTORY SYSTEMS

Refractory Systems

Corrosion Behavior of Tundish Refractories by Molten Steel and Tundish Flux	1256
<i>Tyler Richards,Ronald J. O'Malley,Jeffrey Smith,Todd Sander</i>	
Ladle Bottom Design for Optimized Steel Flow and Metallic Yield	1266
<i>Haysler Lima,Vladnilson Ramos,Douglas Galesi</i>	

Volume III

MATERIAL HANDLING/TRANSPORTATION & LOGISTICS

Material Handling/Transportation & Logistics

How to Improve the Quality of Inbound Scrap	1276
<i>Thomas Saccamozone</i>	
The State of the Art in Magnetic Drum Separators for Scrap	1283
<i>Thomas Saccamozone</i>	

CRANES

OHC Safe & Reliable Handling

Crane Rail Alignment Mapping Using Laser Scanner Point Cloud	1293
<i>Sagar Deshpande,Michael Falk,Nathan Plooster</i>	

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	1299
<i>Alexander Fleischanderl,Thomas Steinpazer,Paul Trunner</i>	

Recovering Fines in Direct Reduction Plants	1308
<i>Ashton Hertrich,Liliana Arsene,Selena Tiburzio,Luca Tommasi</i>	
Clean Steel for New Environmental Opportunities: A Very Important Role for the Steel Industry in the New Industrialized Era	1318
<i>Giorgio G. Parodi,Edward Canepa</i>	
Assessment of a Methodology to Measure Carbon Footprint and Support Decision-Making Process in a Company's Supply Chain	1324
<i>Gustavo Gilberti,Edenilson Silva Filho,Thais Carreira</i>	
New EAF Dust Treatment Process for Co-Production of Metallic Zinc and Calcium-Ferrite	1335
<i>Shunsuke Koide,Hitoshi Mizuno,Kazuyoshi Yamaguchi,Fumio Tanno,Tetsuya Nagasaka</i>	

Cokemaking & Ironmaking

Development and Successful Evaluation of an Atmosphere-Controlled Furnace for Direct Reduction Feedstock Studies	1345
<i>Michael Nispel,Bryan Souchon,Felix Firsbach</i>	
Hisarna: Benefits of a New Developed Smelting-Reduction Option for Ironmaking	1356
<i>J. L. T. Hage,Christiaan Zeilstra,Johan Van Boggelen,H. K. A. Meijer,J. Van Der Stel,T. Peeters</i>	
Modernization of DRI Shaft Furnaces to Improve Performance and Product Quality	1368
<i>Yakov Gordon,N. A. Spirin</i>	
Blast Furnace Data Validation Using Deep Learning as an Enabler for Autonomous Blast Furnace	1378
<i>Cedric Schockaert,Fabrice Hansen,Franck Giroladini,Alexander Schmitz</i>	
Maintenance for Ironmaking Becomes Smart: The Power of Digitizing, Sharing and Linking Valuable, Empirical Knowledge.....	1390
<i>Stephan Weyer,Fabrice Hansen,Yves Reuter,Alexander Schmitz</i>	
Top Gas Recycling Revisited to Reduce Blast Furnace CO ₂ Emissions.....	1400
<i>Mitren Sukhram,Kyle Lefebvre,Nicholas Aubry,Ian Cameron,Ben Ellis,Xinliang Liu,Tom Honeyands</i>	
Blast Furnace Energy Balance — A Sensible Heat Approach	1413
<i>John Busser</i>	
Blast Furnace Flame Temperature Calculation Improvements.....	1425
<i>John Busser</i>	
Coal Rheology — The Effect of Rank and Sample Preparation on Test Results	1439
<i>Ted Todoschuk,Louis Giroux</i>	
Effective Utilization Techniques for Coal Having High Maximum Fluidity Based on Unique Permeation Distance Evaluation.....	1446
<i>Yusuke Dohi,Kiyoshi Fukada,Takashi Matsui,Tetsuya Yamamoto,Mikiya Nagayama,Daisuke Igawa,Issui Akishika,Hiroyuki Sumi,Izumi Shimoyama</i>	
The Influence of Coke Reactivity on the Raceway Size — A Case Study	1460
<i>Markus Bösenhofer,Eva-Maria Wartha,Franz Hauzenberger,Christoph Feilmayr,Hugo Stocker,J. Rieger,Magdalena Schatzl,Michael Harasek</i>	

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
<i>Biswajit Seal, Subal Kumar Saha, Dushyant Kumar, Mantu Patra, Mayank Tiwari</i>	
30+ Year Campaign of IJmuiden Blast Furnace No. 6.....	1479
<i>Frank Kerkhoven, J. Stuurwold, G. Tijhuis, B. Nugteren, Reinoud Van Laar</i>	

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
<i>Bipin Richharia, T. Nagarajan, Juan Ramon Fernandez, Neeraj Shukla</i>	
Comprehensive Process Optimization for Electric Steelmaking Route.....	1498
<i>Richard Stadlmayr, Andreas Rohrhofer, Franz Hartl</i>	
Dolime-Based EAF Hot Repair Material — Successful Product Improvements	1506
<i>Felix Firsbach, Guillaume Bruel, Ian Houldsworth, Jonathan Guest, Souliyann Chunlamani</i>	
Optimization of Electrode Consumption in EAF for Different Operating Conditions	1517
<i>Bipin Richharia, T. Nagarajan, Juan Ramon Fernandez, Manendra Sharma</i>	
Value Creation of Dolime Compared to MgO Alternatives for EAF Application	1528
<i>Eric Perrin, Felix Firsbach, Michael Nispel, John Beatty, William Johnson</i>	
State-of-the-Art Converter Technology: Proven Features for Longest BOF Lifetime	1541
<i>Günther Staudinger, Michael Skorianz, Joachim Lehner</i>	
Analysis of Heat Loss in Oxygen Steelmaking	1553
<i>Nirmal Madhavan, Geoffrey Brooks, M. A. Rhamdhani, B. K. Rout, F. N. H. Schrama, A. Overbosch</i>	
Functionalization of Supersonic Oxygen Lance for EAF	1560
<i>Masashi Yamaguchi, Yasuyuki Yamamoto, Yoshiyuki Hagihara</i>	

Refining & Casting

Basic Actions to Prevent Continuous Casting Defects of Billets	1572
<i>José Bacalhau, Jose Bolota, Danilo Guzela, Marcos Nogueira</i>	
Inclusion Shape Control Through Ca Treatment.....	1585
<i>Keyan Miao, Muhammad Nabeel, Neslihan Dogan, Stanley Sun</i>	
Study on Production Technology of Clean Steel in Phase II of Shougang Jingtang United Iron and Steel Co.	1593
<i>Liu Jingang, Hao Ning, Ji Chenxi, Zhu Zhiyuan, Zhu Guosen, Li Haibo, Li Zhanjun, Chu Rensheng, Yang Rongguang, Wang Guolian, Gao Chongguang, Yan Zhanhui, Shi Shudong</i>	
Influence of Mold Powder Slag Composition on Formation of Oxide Particles in Steel	1600
<i>Junya Ito, Yukimasa Iwamoto, Jim Gilmore, Masanori Okada</i>	
Safety-Certified Positioning and Anti-Collision System at Steel Mill Cranes	1610
<i>Thomas Brandenburger, Peter Haarhoff</i>	

Investigation on Flying Tundish Change and Separation Plate Using Micro-X-Ray Fluorescence at ArcelorMittal Dofasco's No. 1 Continuous Caster	1616
<i>Jackie Leung, Manh Kha Trinh</i>	
Digital Optimization of Refractory Maintenance	1625
<i>Nikolaus Mutsam, Franz Pernkopf, Gregor Lammer</i>	
In-Plant Observations and Thermomechanical Modeling of Different Vessel Types Applying an Insulation Layer	1635
<i>Lionel Rebouillat, Shengli Jin</i>	
Gas Bubble Digital Data Generation by Image Analysis Using Reduced-Scale Water Modeling of a Slab Continuous Caster Mold	1642
<i>Soumitra Kumar Dinda, Amiy Srivastava, Kinnor Chattopadhyay, Joydeep Sengupta</i>	
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
<i>Amiy Srivastava, Soumitra Kumar Dinda, Kinnor Chattopadhyay, Joydeep Sengupta</i>	
Use of Discrete-Event Simulation for Production Expansion Planning at NLMK Indiana LLC	1667
<i>Emily Valley, Russell Sindrey, Randal Beardsley, Steve Ryan</i>	
History and Latest Technology of Castables for Steel Ladles of Japanese Integrated Steel Mills	1679
<i>Masafumi Nishimura, Koji Asakawa</i>	

Rolling & Processing

Automatic Pilot For Strip Processing Lines	1694
<i>Etienne Menigault, Philippe Rocabois, Maxime Monnoyer, Arnaud Ollagnier, Aldo Fiorini, Stefano Pantarotto, Alessandro Ferraiuolo</i>	
Cutting-Edge Process Technologies to Enhance Electrical Steel Performances	1704
<i>Camille Moukarzel</i>	
Development of Electrical Discharge Coating for Extended Textured Roll Campaigns	1712
<i>Chris Childs, G. Evans, T. Lowbridge</i>	
Design and Application of an Optimum Roughing Mill Backup Roll Contour in a Hot Strip Mill	1718
<i>Mustafa Saygili, Özkan Özkan</i>	
Heat Transfer Modeling and Adjustment From Radar Measurements in Reheating Steel Furnaces	1725
<i>Patrik Ottosson, Fredrik Blomqvist, Daniel Andersson, Tomas Ekman</i>	
A Machine-Learning Approach for Steel Grade Detection in Hot Rolling Mills	1742
<i>Pedro Emilio Gazola, H. S. O. Dos Santos, M. Daroit, A. Locatelli</i>	
Key Challenges for Efficient Descaling	1747
<i>John Hinton, J. Lee</i>	
Hot Rolling Coil Technology Development for Pipes Intended for Extraction and Transportation of Petroleum Products	1758
<i>Aleksei Ogoltsov, Artem Mitrofanov</i>	
Microstructure and Property Investigations for Heavy-Gauge Line Pipe Development	1770
<i>Michael Gaudet, Jing Su, Muhammad Rashid, Gail Smith, Kendal Dunnnett, Muhammad Arafin</i>	

Steel Rolling Mill Crop Cobble Shear Operation Improvement — Time Tail Cut	1781
<i>Gary Ng, Shawn Caljouw</i>	

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

Metallurgy

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

IR Temperature Measurement to Monitor Induction Hardening Processes.....	1809
<i>Daniel Schueftan, Janelle Coponen</i>	

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

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

Investigation of Optimal Continuous Casting Condition for Superior Steel Cleanliness	1829
<i>Bikram Konar, Jyoti Saroop, Shaojie Chen</i>	

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

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

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

VIRTUAL PROGRAM

Digitalization

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

VIRTUAL PROGRAM

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

Mastering Fully Automated Steelmaking.....	1894
<i>Richard Stadlmayr, Christoph Stangl</i>	

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

Author Index