FOREWORD

This publication records the proceedings of the Twelfth International Ferroalloys Congress, INFACON XII, held in Helsinki, Finland on June 6-9, 2010. The Proceedings serve as a valuable record of the papers presented at this important event.

The Congress theme ‘Sustainable Future’ is very appropriate at the prevailing world situation in 2009 and 2010. The ferroalloy industry has suffered from the global economic recession calling for ever improved production efficiency. At the same time, demands for concrete measures to respond to global warming have been growing. The papers presenting research work and improvements in design and operating practices are among the topics addressed at INFACON XII and in these Proceedings. The theme reflects the innovations and development required in the ferroalloy industry and the essential role that technology plays in coping with the challenges ahead.

The call for papers was well received and altogether 128 abstracts of very good quality were sent for review. The Program Committee accepted preliminary 120 papers for the evaluation of competent referees.

The Proceedings of INFACON XII contain 97 papers, of which 78 papers to be presented in twentyfive Sessions, by authors from 22 countries. The major ferroalloys, namely ferrochromium and ferromanganese, are covered extensively in many interesting papers. Papers on ferronickel, titanium oxide, silicon and ferrosilicon ensure that all the large-volume ferroalloys are addressed.

These Proceedings will be available both in a printed and electronic form with search function.

All papers included in these Proceedings were pre-reviewed by at least two referees. About 80 referees were sourced internationally, and their valuable technical and editing inputs are gratefully acknowledged. We appreciate the time and effort that the authors and referees have devoted to making this publication a really valuable document.

When INFACON XII was honoured to Finland, for the first time, a group representing Outotec Oyj, Outokumpu Oyj, Aalto University, University of Oulu and Confedent International Oy was formed for the practical organising work. We appreciate these organisations for providing highly competent persons to the Organising and Programme committees. To achieve a broader perspective for the organising work, an international Extended Programme Committee was nominated. We are grateful for the contributions of the members of the Committee.

Finally, I would like to thank the members of the Organising Committee and the Program and Extended Program Committees, led by Dr. Kari Knuutila as well as the Congress Secretary Dr. Asmo Vartiainen and Ms. Eila Paatela, whose contribution for publications and other congress preparation was essential. Without the tireless efforts of these individuals and their Committee members, the technical programme and these Proceedings would not have been the success they certainly are.

Jorma Daavittila
Chairman: INFACON XII Organising Committee
On behalf of the International Committee on Ferro-alloys (ICFA) it gives me great pleasure to welcome all the contributors to and participants at INFACON XII in Helsinki. I would in particular like to acknowledge the leading role of the Chairman of the INFACON XII and the Organising Committee as well as the enormous efforts of all the INFACON XII Sub-Committees in the build-up to INFACON XII over the past three years. The record contribution of high quality and very relevant manuscripts bears testimony to their excellent efforts and to the choice of a topical theme, namely ‘Sustainable Future’.

The Programme Committee, chaired by Kari Knuutila has had a major task with reviewing the numerous abstracts that were submitted and the subsequent refereeing process that is so essential to maintaining and even improving the high technical standards set in the past by previous INFACON Congresses. It is particularly pleasing that INFACON XII has attracted contributions from Russian speaking regions such as Kazakhstan, the Ukraine, and Russia itself. The ICFA Committee requested the Organising Committee of INFACON XII to pay special attention to the need to grow the involvement from the region and their special efforts have been rewarded.

ICFA awarded INFACON XII to Finland based on the excellent presentation given at its Committee meeting in Delhi at INFACON XI. It is gratifying to have seen the very well planned and thoroughly organised management of the activities in the build-up to INFACON XII. With most previous INFACON Congresses this role has been fulfilled by a Professional Association. However in the case of INFACON XII this role has been filled largely by Outotec Oyj (with valuable contributions from Outokumpu Oyj and Aalto University and University of Oulu) who should be acknowledged and sincerely thanked for this tremendous and much appreciated invaluable support for INFACON XII. Special mention should be made of the Chairman, Jorma Daavittila, the Chairman of the Programme Committee, Kari Knuutila, and the Congress Secretary, Asmo Vartiainen, and all their fellow Committee Members. The innovation of forming an INFACON XII Extended Programme Committee to assist with the planning and implementation of the Congress is an excellent one that I feel sure future INFACONs will embrace.

The ICFA Committee plans to hold its next meeting during INFACON XII and announce the host for INFACON XIII planned for 2013 at the end of INFACON XII. We look forward to a truly interesting technical and a most enjoyable social programme during INFACON XII as well as the support of all the ferro-alloy producers and the maximum level participation from all the ferro-alloy producing regions.

Nic Barcza, Chairman ICFA (International Committee on Ferro-alloys)

Secretariat - Mintek, Private Bag X3015, Randburg, 2125, South Africa

Secretary General: T R Curr TomC@mintek.co.za
INFACON XII COMMITTEES

ORGANISING COMMITTEE
Jorma Daavittila, Outotec Oyj (Chairman)
Kari Knuutila, Outotec Oyj
Eila Paatela, Outotec Oyj
Mark Tatarinov, Outotec Oyj
Asmo Vartiainen, Outotec Oyj (Congress secretary)
Katri Luomanpää, Confedent International Oy
Minna Sauramaa, Confedent International Oy
Johanna Vappula, Confedent International Oy

PROGRAM COMMITTEE
Dr. Kari Knuutila, Outotec Oyj, Finland (Chairman)
Mr. Johan Basson, Outotec Ltd, South Africa
Dr. John Bustnes, Elkem Technology Projects, Norway
Mr. Jorma Daavittila, Outotec Oyj, Finland
Prof. Michael Gasik, Helsinki University of Technology, Finland
Prof. Sergei Grischenko, Ministry of Industrial Policy of Ukraine, Ukraine
Prof. Lauri Holappa, Helsinki University of Technology, Finland
Prof. Jouko Härkki, University of Oulu, Finland
Mr. Helge Krogerus, Outotec Research Oy, Finland
Academ. Leopold Leontiev, Institute of Metallurgy of Ural branch of RAS, Russia
Mr. Pekka Niemelä, Outokumpu Oyj, Finland
Prof. Sesdhadri Seetharaman, KTH - Royal Institute of Technology, Sweden
Dr. Niilo Suutala, Outokumpu Oyj, Finland
Prof. Merete Tangstad, Norwegian University of Science and Technology, Norway
Prof. Manat Tolymbekov, Chemical Metallurgical Institute, Kazakhstan
Prof. Jan-Olov Wikström, Swerea MEFOS AB, Sweden
Dr. Asmo Vartiainen, Outotec Oyj, Finland (Congress secretary)
### INFACON XII REFEREES

<table>
<thead>
<tr>
<th>Name</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guven Akdogan</td>
<td>Rauno Luoma</td>
</tr>
<tr>
<td>Nic Barcza</td>
<td>Noel Machingawuta</td>
</tr>
<tr>
<td>Johan Basson</td>
<td>Thomas Magnussen</td>
</tr>
<tr>
<td>Paul Brereton-Stiles</td>
<td>Bodil Monsen</td>
</tr>
<tr>
<td>John Bustnes</td>
<td>Helena Moosberg-Bustnes</td>
</tr>
<tr>
<td>Tom Curr</td>
<td>Theo Morkel</td>
</tr>
<tr>
<td>Jorma Daavittila</td>
<td>Pasi Mäkelä</td>
</tr>
<tr>
<td>Timo Fabritius</td>
<td>Lloyd R. Nelson</td>
</tr>
<tr>
<td>Andrie Garbers-Craig</td>
<td>Pekka Niemelä</td>
</tr>
<tr>
<td>Michael Gasik</td>
<td>Johan Oosthuizen</td>
</tr>
<tr>
<td>Sergei Grischenko</td>
<td>Andreas Orth</td>
</tr>
<tr>
<td>Mårten Gørnerup</td>
<td>Oleg Ostrovski</td>
</tr>
<tr>
<td>C.N. Harman</td>
<td>Joo Hyun Park</td>
</tr>
<tr>
<td>Peter C. Hayes</td>
<td>Chris Pistorius</td>
</tr>
<tr>
<td>Lauri Holappa</td>
<td>Hilgard Rademeyer</td>
</tr>
<tr>
<td>Paavo Hooli</td>
<td>John Rankin</td>
</tr>
<tr>
<td>R. Hurman Eric</td>
<td>Eli Ringdalén</td>
</tr>
<tr>
<td>Markku Huvinen</td>
<td>Antti Roine</td>
</tr>
<tr>
<td>Marko Hämäläinen</td>
<td>T.K. Roy</td>
</tr>
<tr>
<td>Jouko Härkki</td>
<td>Gudrun Saevarsdottir</td>
</tr>
<tr>
<td>Heikki Jalkanen</td>
<td>Pekka Santala</td>
</tr>
<tr>
<td>Petri Jokinen</td>
<td>Sesdhadri Seetharaman</td>
</tr>
<tr>
<td>Rodney T. Jones</td>
<td>Frank Stober</td>
</tr>
<tr>
<td>Laszlo Kadar</td>
<td>Niilo Suutala</td>
</tr>
<tr>
<td>Mauri Kauppi</td>
<td>Merete Tangstad</td>
</tr>
<tr>
<td>Marko Kekkonen</td>
<td>Pekka Taskinen</td>
</tr>
<tr>
<td>Ilkka Kojo</td>
<td>Manat Tolymbekov</td>
</tr>
<tr>
<td>Narayanaswamy Krishnaswamy</td>
<td>Gabriella Tranel</td>
</tr>
<tr>
<td>Helge Krogerus</td>
<td>Roger Urquhart</td>
</tr>
<tr>
<td>Dieter Ksinsik</td>
<td>Asmo Vartiainen</td>
</tr>
<tr>
<td>Markku Kytö</td>
<td>Jan-Olov Wikström</td>
</tr>
<tr>
<td>Jurek Latusek</td>
<td>Yanping Xiao</td>
</tr>
<tr>
<td>Tor Lindstad</td>
<td>Onuralp Yucel</td>
</tr>
</tbody>
</table>

The Twelfth International Ferroalloys Congress
Sustainable Future
June 6 - 9, 2010
Helsinki, Finland
INFACON XII SPONSORS

PLATINUM SPONSOR

Outotec

GOLD SPONSORS

Outokumpu

HATCH
# TABLE OF CONTENTS

## PLENARY PRESENTATIONS

<table>
<thead>
<tr>
<th>Title</th>
<th>Author(s)</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toward sustainability in ferroalloys production</td>
<td>L. Holappa</td>
<td>1-10</td>
</tr>
</tbody>
</table>

## STATUS OF FERROALLOYS INDUSTRY

<table>
<thead>
<tr>
<th>Title</th>
<th>Author(s)</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current situation and main trends of development of Russian ferroalloys industry</td>
<td>L.I. Leontyev, V.I. Zhuchkov</td>
<td>23-28</td>
</tr>
<tr>
<td>Current state and prospects of ferroalloy industry in Kazakhstan</td>
<td>M. Tolymbekov, S. Baisanov, S. Kim</td>
<td>29-33</td>
</tr>
</tbody>
</table>

## HEALTH

<table>
<thead>
<tr>
<th>Title</th>
<th>Author(s)</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioaccessibility of ferro-chromium and ferro-silicon-chromium particles compared to pure metals and stainless steel - aspects of human exposure</td>
<td>K. Midander, A. de Frutos, Y. Hedberg, G. Darrie, I. Odnevall</td>
<td>43-51</td>
</tr>
<tr>
<td>Theoretical and practical aspects of Cr(VI) in the South African ferrochrome industry</td>
<td>JP Beukes , NF Dawson and PG van Zyl</td>
<td>53-62</td>
</tr>
</tbody>
</table>

## ENVIRONMENT – GENERAL

<table>
<thead>
<tr>
<th>Title</th>
<th>Author(s)</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>How the ferroalloys industry can meet greenhouse gas regulations</td>
<td>T. Lindstad, B. Monsen and K. S. Osen</td>
<td>63-70</td>
</tr>
<tr>
<td>Meeting the challenge of sustainability through technology development and integration in ferrochrome submerged arc furnace plant design</td>
<td>M. Dos Santos</td>
<td>71-80</td>
</tr>
<tr>
<td>Recycling of waste materials from the production of FeMn and SiMn</td>
<td>S. Gaal, M. Tangstad , B. Ravary</td>
<td>81-87</td>
</tr>
<tr>
<td>A model for temperature measurement errors in off-gas channels</td>
<td>B. Solvang and E. Næss</td>
<td>89-97</td>
</tr>
</tbody>
</table>
**ENVIRONMENT – FURNACES**

**Improving environment in the tapping area of a ferromanganese furnace**

B. Ravary and S. Grådahl ........................................................................................................ 99-107

**Silicon process: new hood design for tapping gas collection**

M. Kadkhodabeigi, H. Tveit and K. H. Berget ...................................................................... 109-119

**Continuous improvement for fugitive emissions control**

L. Gunnewiek, B. Ravary, P. Cowx, and J. Woloshyn ........................................................... 121-129

**Design of tapping fume extraction systems for ferroalloy furnaces**

L. Els, C. Coetzee, O. Vorster .................................................................................................. 131-141

**ENVIRONMENT – DUSTS**

**Processing of manganese furnace dust: drying and zinc oxide reduction**


**Major ferroalloy producer improves furnace fume control system by installing baghouse with membrane filter bags**

L. Els, F. Fereday, O. Vorster ................................................................................................... 155-165

**Low temperature carbothermal reduction of siliceous manganese fines**

R. Kononov, O. Ostrovski and S. Ganguly ............................................................................. 167-177

**RECOVERY FROM DUSTS AND SLAGS**

**Vanadium recovery as FeV from petroleum fly ash**

Y. Xiao, C. R. Mambote, H. Jalkanen, Y. Yang and R. Boom .............................................. 179-188

**Recovery of vanadium from V-bearing BOF-slag using an EAF**

M. Lindvall, S. Rutqvist and G. Ye ......................................................................................... 189-195

**High purity Mn metal from Mn oxide dust produced by FeMn refining process**

K.J. Lee, D.S. Min, C.S. Park, Y.K. Park, H.C. Jo, S.H. Hong ............................................... 197-205

**MODELLING AND SIMULATION**

**Thermodynamical computations in carbothermal and metallothermic ferroalloy processes**

B. Derin, O. Yucel, K. Hack ..................................................................................................... 207-213

**Building a FeNi smelter simulator**

H. Oterdoom and R. Degel ...................................................................................................... 215-227

**A thermodynamic study on the oxidation of silicon, carbon and chromium in the ferrochrome converter**

E-P. Heikkinen, T. Ikäheimonen, O. Mattila and T. Fabritius ................................................ 229-237

**FERROCHROMIUM FUNDAMENTALS**

**Thermodynamic analysis of chrome reduction with aluminum and silicon**

A. Akuov, M. Tolymbekov, B. Kasenov and A. Yesenzhulov ............................................ 239-243

**Petrographic analysis of low-carbon ferrochrome slags**

A. Konarbaeva, A. Akuov, M. Tolymbekov ........................................................................... 245-248
FERROCHROMIUM – PRETREATMENT FOR SMELTING

Pre-reduction and smelting characteristics of Kazakhstan ore samples

S. McCullough, S. Hockaday, C. Johnson and N.A. Barcza ................................................................. 249-262

Effects of oxidation on the microstructure and reduction of chromite pellets

B. Zhao and P.C. Hayes .................................................................................................................. 263-273

Research & development initiatives on the briquetting technology and its commercialisation for Richards Bay plant

R. Sen, D. Mukherjee, J. J. Van Vuuren, W. DeVilliers, S. Banerjee ............................................. 275-282

Research of briquetting process of fine chromic ores

A.V. Pavlov, Y.V. Zavalishina, V.A. Grygorian, K.L. Kossyrev, and O.V. Chadaeva .................. 283-292

Coal based direct reduction of preoxidized chromite ore at high temperature

G. Kapure, V. Tathavadkar, C.B. Rao, S.M. Rao, K.S. Raju .......................................................... 293-201

FERROCHROMIUM SMELTING

A laboratory investigation of influence of electric current on the burden reactions in a submerged arc furnace

A. Rousu, O. Mattila and P. Tanskanen ............................................................................................ 303-310

Utilization of substandard and offgrade raw materials for chromium and manganese ferro-alloys production

V.I. Zhuchkov, O.V. Zayakin, A.V. Zhdanov .................................................................................. 311-315

Preliminary characterization of the samples taken from a submerged arc ferrochrome furnace during operation

J. Ollila, P. Niemelä, A. Rousu and O. Mattila .............................................................................. 317-326

REDUCTANTS

Slag-carbon reactivity

J. Safarian and M. Tangstad ............................................................................................................. 327-337

Modelling and optimisation of anthracite treatment in an electrocalcinator


Influence of coke particle size on the electrical resistivity of coke beds

P. A. Eidem, M. Tangstad, J. A. Bakken and R. Ishak ................................................................. 349-358

Reductant characterization and selection for ferrochromium production

G. Makhoba, and R. Hurman Eric .................................................................................................... 359-365

FERROCHROMIUM PRODUCTION

Some aspects of the production of ferrochrome alloys in pilot DC arc furnaces at Mintek

S.A.C. Hockaday and K. Bisaka ........................................................................................................ 367-376

Process for effective utilization of low grade chromite overburden

G. Kapure, C.B. Rao, V. Tathavadkar, K.S. Raju ........................................................................... 377-382

Reduction of chromite fines in solid state using a mixture of gases containing natural gas, hydrogen and nitrogen

C.N. Harman ........................................................................................................................................ 383-390
Zimbabwe alloys ferro chromium production: from cradle to grave sustainably
J. Chirasha and N.R. Shoko ................................................................. 391-399

Simulation of the production of ferro-chromium in submerged-arc furnace

FERROCHROMIUM REFINING
Oxidation kinetics of ferrochrome under controlled oxygen pressures
H. Wang, N.N. Viswanathan and S. Seetharaman ........................................ 411-419

Refining of charge-chrome; a study of some products and applications
C-J. Rick ........................................................................................................ 421-430

The aluminothermic production of extra low carbon ferrochromium from low grade chromite ore

FERROMANGANESE – PRETREATMENT FOR SMELTING
Properties of manganese ores and their change in the process of calcination

Decrepidation of Brazilian manganese lump ores

Behavior of agglomerates in ferromanganese production
M. M. Tangstad, D. Leroy, E. Ringdalen .................................................... 457-465

Upgrading of Mn / Fe ratio of low-grade manganese ore for ferromanganese production
V. Kivinen, H. Krogerus and J. Daavittila .................................................... 467-476

The effect of potassium and zinc circulation on agglomeration of a charge in SAF
D. Slizovskiy, M. Tangstad ........................................................................ 477-485

Ore properties in melting and reduction reactions in siliconmanganese production
E. Ringdalen, O. Ostrovski, S. Gaal ............................................................... 487-496

FERROMANGANESE SMELTING
Comparing manganese ferroalloy smelting in pilot-scale AC and DC submerged-arc furnaces
H. Lagendijk, B. Yakalashe, T. Ligege, P. Ntikang and K. Bisaka ......................... 497-507

Operational improvements of a submerged arc furnace in Kashima works (KF-1) relined in 2006
T. Ishitobi, K. Ichihiara, T. Homma ................................................................ 509-515

Complex processing of iron-manganese ore of central Kazakhstan
Ye. Samuratov, A. Baisanov, M. Tolymbekov ............................................ 517-520

Furnace management in Eramet Manganese during the 2009 crisis
G. Folmo, C. Perdon, T. Hitier, R. Ishak, F. Wasser, D. Haaland ......................... 521-530

Influence of boron oxide on viscosity and conductivity of CaO-SiO2-Al2O3-MgO-MnO slags
O. Sariev, M. Tolymbekov, A. Akberdin, A. Kim ........................................ 531-535

Multi-variation analysis and optimisation of electrical conductivity of MnO-SiO2-CaO slags
M. M. Gasik, M. I. Gasik ............................................................................. 537-545
FERROMANGANESE REFINING

Manganese ore and alloys piloting tools at Eramet research
A.Soller, A. Amalric, G. Pochart and G. Nussbaum ............................................................. 547-555

Reaction of manganese containing slag with carbon substrate
H. Sun, M. Lone, S. Ganguly and O. Ostrovski ................................................................. 557-567

Electric parameters for an efficient smelting performance of HCFeMn alloy
Y. E. Lee and M. Tangstad ............................................................... 569-578

Development of a dynamic model of the manganese oxygen refining (MOR) converter
J. Nell, I. Nolet ............................................................... 579-587

Thermodynamical aspects of decarburization of manganese melts
V.Va.Dashevskiy, A.G.Kanevskiy ................................................................. 589-599

Thermodynamics of carbon removal by molten slags from manganese alloy melts
J.H. Park, G.H. Park, C.I. Park, J.G. Park, D.J. Min, H.C. Jo, Y.E. Lee ........................................ 601-610

Kinetic of nitriding process of ferromanganese alloy
S.N. Ghali, K.M. El- Fawakhry, M.M. Eissa and M.L. Mishreky ........................................ 611-617

OTHER FERROALLOYS FUNDAMENTALS

Thermochemical and kinetic databases for the solar cell silicon materials
K. Tang, E.J. Øvrelid, G. Tranell, M. Tangstad ............................................................. 619-629

Slag phase equilibria and viscosities in ferronickel smelting slags
E. Jak and P.C. Hayes ........................................................................................................ 631-639

Phenomena in thermal treatment of lateritic nickel ores up to 1300°C
A. Bunjaku, M. Kekkonen and L. Holappa ............................................................. 641-652

Phase diagram of Ti-Fe-Al system
Ye. Zhumagaliev, S. Baisanov, A. Chekimbaev, N. Nurgali ........................................ 653-656

Thermal analysis of agglomerated nickel ore
B. Kelamanov, M. Tolymbekov, K. Kaskin, A. Baisanov ........................................ 657-659

Small scale laboratory experiments simulating an industrial silicon furnace
M. Tangstad, M. Ksiazek, V. Andersen, E. Ringdalen ........................................ 661-669

FERRONICKEL SMELTING

Relevant aspects related to production of iron nickel alloys (pig iron containing nickel) in mini blast furnaces
P. von Krüger, C.A. Silva, C. Batista Vieira, F.G.S. Araújo, V. Seshadri ................................ 671-680

High power, shielded-arc FeNi furnace operation - challenges and solutions
C. Walker, T. Koehler, N. Voermann and B. Wasmund ........................................ 681-696

SNNC: a new ferronickel smelter in Korea
FERROSILICON SMELTING

Reaction zones in a FeSi75 furnace - results from an industrial excavation
G. Tranell, M. Andersson, E. Ringdal, O. Ostrovski and J. J. Steinmo ........................................ 709-715

Current distribution in submerged arc furnaces for silicon metal / ferrosilicon production
G. Saevarsdottir and J. A. Bakke ........................................................................................................ 717-728

Energy balance of a 45 MW (ferro-) silicon sub-merged arc furnace
N. E. Kamfjord, E H. Myrhaug, H Tveit and B. Wittgens ................................................................. 729-738

Waste heat utilization from a submerged arc furnace producing ferrosilicon
G. Saevarsdottir, H. Hjartarson, H. Palsson ....................................................................................... 739-748

ENGINEERING ASPECTS

New TiO2 slag plant for CYMG using 30 MW DC furnace
A. de Jong, D. Mitchell ......................................................................................................................... 749-757

SAF water leak detection by the measurement of gaseous water vapour
P. Dennis, S. Ganguly .......................................................................................................................... 759-768

Application of high intensity refractory cooling systems in pyrometallurgical vessel design
F. Marx, M. Shapiro, B. Henning ......................................................................................................... 769-778

ENGINEERING ASPECTS – FURNACES

Advanced modelling and baking of Söderberg electrodes
RP Meyjes, J Venter and U Van Rooyen ............................................................................................. 779-788

Mathematical and computational modelling of the dynamic behaviour of direct current plasma arcs
Q.G. Reynolds, R.T. Jones and B.D. Reddy ......................................................................................... 789-801

Low cost ferroalloy extraction in DC-arc furnace at Middleburg Ferrochrome
D. Sager, D. Grant, R. Stadler and T. Schreiter .................................................................................. 803-814

Developments in the design and construction of DC arc smelting furnaces
F.P. Greyling, W. Greyling and F.I. de Waal ...................................................................................... 815-823

AC- and DC- smelter technology for ferrous metal production
G. Kleinschmidt, R. Degel, M. Köneke, H. Oterdoom ...................................................................... 825-838

Implementation of the first commercial scale DC smelter for ferronickel production from low grade
lateritic ores - technology building blocks and lessons learned
C.P. Naudé and M.D. Shapiro ............................................................................................................. 839-848

Evaluating AC and DC furnace water cooling systems using CFD analysis
B. Henning, M. Shapiro, F. Marx, D. Pienaar and H. Nel ................................................................... 849-856

Campaign extensions for ferroalloy furnaces with improved taphole repair system
C. Coetze, P.L Duncanson, P. Sylven ................................................................................................. 857-865

New developments in furnace power stabilization with SPLC
M. Sedighy, T. Ma, N. Voermann ........................................................................................................ 867-879
ENGINERING ASPECTS – LININGS

Refractory wear and lining profile determination in operating electric furnaces using stress wave non-destructive testing (NDT)

A. Sadri, P. Gebski, E. Shameli ........................................................................................................... 881-890

New refractory lining direction at Jindal Stainless FeCr #1 and #2 furnaces

C. Coetzee, P.H. Lamont, P.L Duncanson, P. Sylven ........................................................................... 891-898

APPLICATIONS AND USES

SHS-technology of ferroalloys nitriding

M. Kh. Ziatdinov, I. M. Shatokhin ........................................................................................................ 899-909

Low-nickel austenitic stainless steels: metallurgical constraints

P.C. Pistorius and M. du Toit .............................................................................................................. 911-917

Ferro-alloy design, ferro-alloy selection and utilisation optimisation with particular focus on stainless steel making materials

C-J Rick, M. Engholm ....................................................................................................................... 919-928

Ferroalloys for clean steels productions and quality specifications

K.V. Grigorovich, S.S. Shibaev, I.V. Kostenko .................................................................................. 929-934

Impurities in commercial ferroalloys and its influence on the steel cleanliness


Contribution maximization model -case of a ferro alloys manufacturing firm

R.K. Mohapatra ................................................................................................................................... 945-952