

The Minerals, Metals and Materials Society

EPD Congress 2006

March 12-16, 2006
San Antonio, Texas, USA

Volume 1 of 2

Printed from e-media with permission by:

Curran Associates, Inc.
57 Morehouse Lane
Red Hook, NY 12571
www.proceedings.com

ISBN: 978-1-60423-654-5

Some format issues inherent in the e-media version may also appear in this print version.

A Publication of TMS (The Minerals, Metals & Materials Society)
184 Thorn Hill Road
Warrendale, Pennsylvania 15086-7528
(724) 776-9000

Visit the TMS web site at
<http://www.tms.org>

Statements of fact and opinion are the responsibility of the authors alone and do not imply an opinion on the part of the officers, staff, or members of TMS, The Minerals, Metals, and Materials Society. TMS assumes no responsibility for the statements and opinions advanced by the contributors to its publications or by the speakers at its programs. Registered names and trademarks, etc., used in this publication, even without specific indication thereof, are not to be considered unprotected by the law.

No part of this book may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, microfilming, recording, or otherwise, without written permission from the publisher.

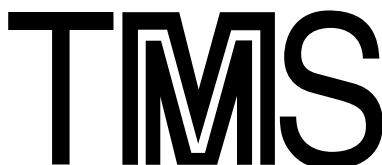
Printed in the United States of America
ISSN Number 1079-7580

Authorization to photocopy for internal or personal use beyond the limits of Sections 107 and 108 of the U.S. Copyright Law is granted by TMS, provided that the base fee of \$7.00 per copy is paid directly to the Copyright Clearance Center, Inc., 222 Rosewood Drive, Danvers, MA 01923 USA, www.copyright.com. Prior to photocopying items for educational classroom use, please contact the Copyright Clearance Center, Inc.

For those organizations that have been granted a photocopy license by the Copyright Clearance Center, a separate system of payment has been arranged.

This consent does not extend to copying items for general distribution or for advertising or promotional purposes or to republishing items whole or in part in any work in any format.

Please direct republication or special copying permission requests to the Copyright Clearance Center, Inc., 222 Rosewood Drive, Danvers, MA 01923 USA; (978) 750-8400; www.copyright.com.



Copyright 2006, The Minerals, Metals, and Materials Society. All rights reserved.

If you are interested in purchasing a copy of this book, or if you would like to receive the latest TMS publications catalog, please telephone (800) 759-4867 (U.S. only) or (724) 776-9000, EXT. 270.

Table of Contents

Volume 1

Extraction and Processing Division

Executive Council
Honors and Awards
Session Chairpersons

Advances in Furnace Integrity

Session I

Acoustic-Pulsation-Based Intensification of Heat Transfer in Continuous Furnaces.....	5
<i>A. Lozhko, and E. Sorokina</i>	
CONSCAN, A Laser Measurement System for Furnaces Which Are Operating on High Temperatures	11
<i>O. Zach, K. Gamweger, and T. Prietl</i>	
Recent Improvements in Evaporative Cooling Technology for Copper Tapholes and Launders	17
<i>P. Navarra, F. Mucciardi, and T. Van Rompaey</i>	

Characterization of Minerals, Metals and Materials

Advances in Minerals and Processing Applications

On-Line Radio Frequency Measurement of Bulk Mineralogy.....	31
<i>D. Bennett, D. Miljak, and J. Khachan</i>	
Robotic Automation of the Fire Assay Process for Rapid Quantitative Measurement of Platinum Group Elements in Mineral Concentrator Plants.....	39
<i>K.S. McIntosh, J.J. Eksteen, and K. Koch</i>	
Using Rietveld Analysis with Topas for Modal Analysis of Geological Samples	49
<i>H. Cordes</i>	
Barite Mineralization in Volcanic Rocks in Southern Flank of East-Magnitogorsk Palaeoisland Arc (South Urals).....	57
<i>N.N. Ankusheva</i>	
Mineralogical and Chemical Characterization of the W-Pb-Bi-Ag Ore from the Rudnik Mine, Serbia	65
<i>S. Radosavljevic, J. Stojanovic, and A. Radosavljevic-Mihajlovic</i>	

Applied Mineralogical Studies on Colombian (El Bagre, Antioquia) Black Sands	73
<i>C.M. Lamus Molina, M.A. Márquez Godoy, and J.C. Gaspar</i>	
Applied Mineralogical Studies of Nigerian Bulk Complex Sulphide Ore	83
<i>P.A. Olubambi, S. Ndlovu, J.H. Potgieter, and J.O. Borode</i>	
Pulsed Power Breaking-Up Technology for Resistant Gold-Containing Ores and Beneficiation Products	93
<i>V.A. Chanturiya, and I.J. Bunin</i>	
The Effect of the Mineralogy of the Platinum Group Metals on Their Leachability During the PLASTOL® Leach Process	103
<i>C.J. Ferron, C.C. Hamilton, O. Valeyev, and N. McKay</i>	
Materials Characterization of Electrocoagulation Byproducts Using Al-Fe Combination Electrode System	119
<i>J.A.G. Gomes, P. Daida, G. Irwin, H. McWhinney, T. Grady, H. Moreno, E. Peterson, J.R. Parga, and D.L. Cocke</i>	

Advances in Metals and Engineered Materials

Adiabatic Shear Bands Associated with Plug Formation and Penetration in Ti-6Al-4V Targets: Formation, Structure, and Performance: A Preliminary Study.....	137
<i>F. Martinez, E.V. Esquivel, M.I. Lopez, S.M. Gaytan, D.A. Lopez, A. Ramirez, D.A. Ramirez, P.A. Guerrero, C. Pizana, I. Anchondo, L.E. Murr, B.E. Schuster, and M. Fermen-Coker</i>	
Comparison of Dislocation and Other Deformation Microstructures in As-Grown, Compression Tested, and Ballistically Penetrated W Single-Crystal Rods	143
<i>M.T. Baquera, L.E. Murr, C. Pizaña, T.L. Tamoria, H.C. Chen, and S.J. Cytron</i>	
Local Thermal Property Analysis by Scanning Thermal Microscopy of Ultrafine-Grained Surface Layer in Copper and in Titanium Produced by Surface Mechanical Attrition Treatment	149
<i>F.A. Guo, Y.N. Zhang, and N. Trannoy</i>	
Temperature Measurements in Microwave Heating.....	1118
<i>X. Sun, J.-Y. Hwang, S. Shi, B. Li, and X. Huang</i>	
Ultrasonic Detection of Hydride Blisters in a Zr-2.5Nb Pressure Tube	159
<i>Y.-M. Cheong, S.-S. Kim, and Y.-S. Kim</i>	
The Characterization of the Intermetallic Fe-Al Layer of Steel-Aluminum Weldings.....	167
<i>M. Potesser, T. Schoeberl, H. Antrekowitsch, and J. Bruckner</i>	
Microstructural Characterization of Mg Based Alloys	177
<i>A.J. Sideris, A.L.D. Skury, S.N. Monteiro, and G.S. Bobrovitchii</i>	
Effect of Retrogression and Reaging Treatment on Stress Corrosion Cracking Resistance of 7075 Aluminum Alloy.....	181
<i>M. Baydogan, H. Cimenoglu, E.S. Kayali, and J. Rasty</i>	

EDXRF Analysis of Alloys and Corrosion Products of Metallic Pre-Hispanic Pieces of the Museum of Ethnology and Archaeology of the University of Sao Paulo	189
<i>A.C. Neiva, J.N. Dron, H.G. de Melo, and S.C. Lima</i>	
Corrosion Processes and Mineral Formation on the Surface of Bronze Monuments in Urban Environments	199
<i>O. Frank-Kamenetskaya, and E. Treivus</i>	
A Study of Accuracy and Reproducibility of High Temperature Differential Scanning Calorimetry.....	209
<i>S. Jacob, and M.E. Schlesinger</i>	
Iron Oxide Reduction with Conventional and Microwave Heating Under Co and H₂ Atmospheres.....	219
<i>J.-Y. Hwang, X. Huang, S. Qu, Y. Wang, S. Shi, and G. Caneba</i>	
Microstructural Characterization of Brazilian Iron Ores for Quality Control in Iron Making – A Geometallurgical Approach	229
<i>V. Seshadri, C.B. Viera, and C.A. Rosiere</i>	
Development of Ore-Coal Composite Pellets for Sponge Ironmaking	241
<i>B.B. Agrawal, and G.I.S. Chauhan</i>	

Advances in Ceramics, Refractories and Composites

Characterization of a Ceramic Foam.....	249
<i>S.N. Monteiro, and C.M.F. Vieira</i>	
Fibrous Reinforcement in Clay-Bonded Silicon Carbide Refractory Using Andalusite Powder	255
<i>B. Li, J.-Y. Hwang, and S. Shi</i>	
Characterization of Some Ceramic Materials for High Pressure Applications.....	263
<i>A.M. Ramalho, G.S. Bobrovitchii, S.N. Monteiro, and M.V. Figueiredo</i>	
Investigation on the Thermal Decomposition of Diaspore.....	273
<i>X. Liu, J. Wang, Y. Hu, Y. Danqing, and H. Li</i>	
Characterization of Clayey Ceramic Body Used for Roofing Tile Fabrication.....	281
<i>C.M.F. Vieira, P.M. Andrade, E.V. Silva, and S.N. Monteiro</i>	
Structural and Morphological Characterization of a Natural Graphite After Application of High Pressure and High Temperature Treatment	289
<i>A.L.D. Skury, G.S. Bobrovitchii, S.N. Monteiro, and L.A.H. Terrones</i>	
Phase Transformation of Andalusite and Its Impacts on Refractory Brick Reinforcement	295
<i>B. Li, J.-Y. Hwang, A.M. Hein, and Z. Xu</i>	
Characterization of Steel Slag for Incorporation Into Red Ceramics	303
<i>S.N. Monteiro, E.L. dos Santos Jr., S.C. Intorne, D.P. Dias, and C.M.F. Vieira</i>	
Phase Changes During Heating of Illite.....	309
<i>X. Liu, H. Li, Y. Hu, D. Yi, and J. Wang</i>	

Pullout Test of Coir Fiber to Evaluate the Interface Strength in Polyester Composites	317
<i>S.N. Monteiro, J.F. de Deus, R.C.P. Aquino, and J.R.M. D'Almeida</i>	
Microstructural Characterization of Epoxy Matrix Composites with Dispersed Diamond Particles	325
<i>S.N. Monteiro, A.L.D. Skury, G.W. Menezes, R.J.S. Rodriguez, and J.R.M. D'Almeida</i>	
The Direct Test of Swell Stress for Geosynthetic Clay Liners.....	335
<i>J. Shen, C. Li, S. He, G. Zhang, J. Tong, and B. Yan</i>	
Environmentally Correct Jute Reinforced Polyethylene Composites.....	349
<i>S.N. Monteiro, A.C. Lima, L.J.T. Petrucci, L.A.H. Terrones, and J.R.M. D'Almeida</i>	
Morphological, Mechanical and Optical Characterization of Flyash Filled Nylon 6	359
<i>P.A. Mahanwar, S. Bose, and H. Raghu</i>	
Mechanical and Structural Characterization of Curaua Fibers	369
<i>S.N. Monteiro, J.F. de Deus, and J.R.M. D'Almeida</i>	

General Abstracts:

Extraction and Processing Division

Copper and Nickel Hydrometallurgy

Development of a Hydrometallurgical Process for Copper Concentrate Treatment by Sumitomo Metal Mining	381
<i>M. Imamura, K. Takeda, K. Ando, N. Nagase, and Y. Ojima</i>	
High Aspect Ratio Nickel Structures Fabricated by Electrochemical Replication of Hydrofluoric Acid Etched Silicon	391
<i>X. Zhang, and K.N. Tu</i>	

Hydrometallurgy

Effect of Normality, Temperature and Time on the Tungsten Losses in The Residue Separated from Diluted Scheelite-Slurry-in-NaOH after Digestion.....	1094
<i>R.P.S. Gaur</i>	
Comprehensive Utilization of Zinc Leach Residues by Flotation – Reduction Roasting - Magnetic Separation Process.....	401
<i>Y. Zhang, Z. Huang, T. Jiang, G. Li, Y. Yang, Y. Guo, and B. Xu</i>	
Study on Recovery of Ferrous Minerals from Nickle Metallurgical Residues by Selective Flocculation-Magnetic Separation	411
<i>Y. Guo, H. Dong, G. Li, Z. Huang, Y. Yang, and T. Jiang</i>	
The Technological Characteristics of Blended Nkalaha and Nsu Clays.....	421
<i>N.E. Idenyi, S.I. Neife, and S.O. Agha</i>	
A Clean Method Applying Anion-Exchange Separation and Membrane-Electrolysis to Regenerate Fe-Zn-HCl Spent Pickling Liquors.....	427
<i>G. Csicsovszki, T. Kékesi, and T.I. Török</i>	

Copper/Nickel

Neutralization of Smelter Gases with Limestone in a Countercurrent Multiple Fluidized Bed System.....	439
<i>I. Wilkomirsky, F. Parada, and R. Parra</i>	
Decomposition Kinetics of Flash Smelting Flue Dust Sulphates	451
<i>E. Nurminen, and P. Taskinen</i>	
Controlling of Foaming Phenomena During Copper Blow in Copper P-S Converter	461
<i>P. Tan, P. Vix, and P. Telford</i>	
Reduction of Nickel Oxide from Liquid Slags with Carbon and Silicon	475
<i>P. Martínez Nicolás, A. Romero-Serrano, S. González-López, and M. Angeles-Hernández</i>	
Energy Requirements in Nickeliferous Laterite Treatment	487
<i>E.N. Zevgolis, C. Zografidis, J. Gaitanatos, I.P. Kostika, and I. Halikia</i>	

Lead and Other Metals

Improving Metallurgical Operations Through Application of Systems Thinking Principles.....	499
<i>K.N. Swamy</i>	
Thermodynamic Modeling of Copper Drossing Process in Lead Refining	509
<i>P. Tan, and P. Vix</i>	
Thermodynamic Modeling of Kivcet Lead Process	517
<i>P. Tan, and P. Vix</i>	
Application of Transformational Roasting to the Treatment of Metallurgical Wastes	525
<i>P.C. Holloway, and T.H. Etsell</i>	

Granulation of Molten Materials Session I

Granulation of Molten Materials	539
<i>D. Norval</i>	
Evolution of Granulation Technology.....	553
<i>W. Van Hooff, B. Greiveldinger, and M. Wenner</i>	

Volume 2

Common Granulation Systems in the Metals Industry.....	567
<i>A. Cooper</i>	
Copper Matte Granulation at the Kennecott Utah Copper Smelter	577
<i>D.B. George, C. Nexhip, D. George-Kennedy, R. Foster, and R. Walton</i>	
Granulation of Precious Metal Bearing Alloys and Slags.....	591
<i>W.K. O'Connor, P.C. Turner, G.E. Rush, and G.F. Soltau</i>	
Multimedia Dispersion and Solidification of Molten Material Flows.....	601
<i>D. Arana, and H. Leroux</i>	
The Properties and Uses of Granulated Non Ferrous Slags	611
<i>M.P. Sudbury, and D.J. Kemp</i>	

Granulation of Molten Materials Session II

Common Granulation System Problems with a Focus on Non-Ferrous Applications.....	623
<i>A. Cooper</i>	
Atomisation as a One Step Process for Hydrometallurgical and Flash Furnace Feed	633
<i>D. Norval</i>	
Atomization of Granules Using a Single Fluid Technique	647
<i>H. Henein</i>	

Materials Processing Fundamentals Process Modeling

Fluid Flow and Transport Phenomena During Steel Refining and Casting Process.....	659
<i>L. Zhang</i>	
Numerical Simulations of Jet Break-Up Phenomena for the High Pressure Die Casting Process.....	669
<i>V. Viti, K. Kuwana, A.S. Sabau, M. Hassan, and K. Saito</i>	
Mathematical Modeling and Design of Heat Pipe-Cooled Metallurgical Furnace Equipment	679
<i>P. Navarra, H. Zhao, F. Mucciardi, and T. Van Rompaey</i>	
Numerical Model of the Temperature Field and Heterogeneity of a Casting of Ductile Cast-Iron.....	689
<i>F. Kavicka, B. Sekanina, J. Heger, K. Stransky, J. Dobrovska, and J. Stetina</i>	
Design of Supersonic Nozzles for Ultra-Rapid Quenching of Metallic Vapours.....	699
<i>M.N.H. Khan, P. Witt, G. Brooks, T. Barton, and M. Nagle</i>	

Study of Non-Wetting Liquid Flow in a Bed of Mono-Sized Particle Packing Under the Influence of Lateral Gas Injection	711
<i>V. Singh, and G.S. Gupta</i>	
Computer Modeling of a Self-Reducing Agglomerate in a Shaft Furnace.....	721
<i>J.C. D'Abreu, H.M. Kohler, J.H. Noldin Jr.</i>	

Solidification and Deformation Processing

Comparative Study of the Effects of Solidification Rate on the Cast Microstructures of Aluminum Alloys 6016 and 6009.....	733
<i>P.N. Anyalebechi</i>	
On Chemical Heterogeneity Measurement and Evaluation in CC Steel Slab ...	745
<i>J. Dobrovska, F. Kavicka, V. Dobrovska, and K. Stransky</i>	
Metallic Wires Elaboration Directly from Thin Liquid Jets	753
<i>L. Charpentier, Y. Duterrail-Couvat, Y. Delannoy, and C. Trassy</i>	
The Model of Structure Refinement in Metals at Large Deformations and Factors Effecting Grain Sizes	763
<i>F.Z. Utyashev, and G.I. Raab</i>	
Age Hardening Behavior of AA2618.....	773
<i>H. Lu, P.B. Kadolkar, K. Nakazawa, T. Ando, and C.A. Blue</i>	
Characterization of Mechanical Properties and Microstructure in Copper Nanopowder Alloyed Al7075 T651 Via Friction Stir Process.....	783
<i>D. Kim, J. Wu, W.F. Schmidt, and A.P. Malshe</i>	

Smelting and Refining

Mechanisms of Oxygen Partial Lead Softening	795
<i>S. Firoozi, D. Vineberg, and R. Harris</i>	
Carbothermal Reduction Study of Kaolin and Two Different Silica Sources ...	805
<i>S. Niyomwas</i>	
Increase in Concentration of a Zn-Containing Volatile Complex by UV Irradiation of a Target for ZnO Films Synthesis.....	813
<i>E. Arakelova, V. Parvanyan, F. Grigoryan, G. Asatryan, and G. Petrosyan</i>	
Preparation of SmCos by Chemical Coprecipitation-Reduction-Diffusion Method (CPRD)	819
<i>L. Ping, G. Xueyi, X. Ping, H. Kai, and L. Rongyi</i>	
Prevention of Resulfurization in Magnesium Desulfurization Process of Molten Iron	827
<i>J. Yang, M. Kuwabara, K. Okumura, Z. Liu, and M. Sano</i>	

Powders and Composites

EMF Study of Nb-Al Intermetallics	841
<i>P. George, and R.G. Reddy</i>	
In Situ Synthesis of Al-TiC-Al₂O₃ and Al-SiC-Al₂O₃ Composites	847
<i>N. Memongkol, and S. Niyomwas</i>	
Effects of Temperature and Precursors on Preparation of Fe-TiC Composite from Ilmenite.....	857
<i>S. Niyomwas</i>	
Preparation of Mono-Dispersed Cobalt Oxide Particles by Homogeneous Precipitation with Urea	865
<i>Q. Bo, G. Xueyi, X. Liu, H. Kai, and R. Liu</i>	
Study of the Metallizing of the Continuous Carbon Fiber Surface.....	875
<i>T. Luo, G. Yao, L. Wu, and Y. Liu</i>	
Study of Decomposition Regularities for a Zn-Containing Volatile Complex Used in ZnO Film Synthesis.....	883
<i>E. Arakelova, F. Grigoryan, V. Parvanyan, and G. Asatryan</i>	
The Formation of Misty Band Near the Substrate During Contact Angle Measurement.....	889
<i>L. Wu, G. Yao, T. Luo, and X. Zhang</i>	

Recycling Electronics Recycling

Metallurgical Recycling of Electronic Scrap.....	899
<i>H. Antrekowitsch, M. Potesser, W. Spruzina, and F. Prior</i>	
Eco-Efficient Recycling Alternatives for End-of-Life Cathode Ray Tubes.....	909
<i>J. Gregory, and R. Kirchain</i>	
Filtration of Solar Cell Silicon Scrap	919
<i>A. Kvithyld, D. Chithambaranadhan, A. Çiftja, E. Øvrelid, and T.A. Engh</i>	
Leaching of Copper from Waste Printed Circuit Boards Using Electrogenerated Chlorine in Hydrochloric Acid Solution.....	929
<i>E.-Y. Kim, M.-S. Kim, J.-C. Lee, J. Jeong, and B.-S. Kim</i>	
Recovery of Tellurium from Cadmium Telluride Photovoltaic Module Manufacturing Scrap and Other Sources.....	935
<i>W. Wang, and V.M. Fthenakis</i>	
A Clean-Lead Factory is Available for Lead-Acid Batteries Recycling by Means of the “Cleanlead Process”	943
<i>C. Frias, N. Ocaña, G. Diaz, T. Piper, B. Bulkowski, A. Chmielarz, P. Claisse, S. Hemmings, L. Abrantes, H. Jansen, J. Van Erkel, T. Franken, Z. Kunicky, and T. Velea</i>	
Cost Analysis of Used Battery Recycling in Taiwan.....	953
<i>E. Hsu, and C.-M. Kuo</i>	

General Recycling

Immobilization Process Via Solidification of Hazardous Heavy Metals for Recycling Industry Waste	963
<i>J.-W. Ahn, K.-S. You, S.-H. Ahn, and H. Kim</i>	
Effect of Magnetic Separation in Removal of Heavy Metals in Municipal Solid Waste Incineration Bottom Ash	967
<i>N.-I. Um, G.-S. You, G.-C. Han, and J.-W. Ahn</i>	
A New Recycle Process of Uranium from Spent Fuel by Selective Sulfurization	973
<i>N. Sato, G. Shinohara, O. Tochiyama, and S. Sato</i>	
Recycling of Oxidic Waste from Ferroalloy Production	979
<i>M. Hohenhofer, H. Antrekowitsch, M. Potesser, and W. Labenbacher</i>	
Repeatedly Utilizing of Carbon Fiber Chemistry Copper Plating Waste Liquid	989
<i>T. Luo, G. Yao, L. Wu, X. Zhang, and H. Li</i>	

Sampling, Sensors & Control for High Temperature Metallurgical Processes

Session I

Challenges in Sampling, Metallurgical Accounting and Reconciliation of Primary Smelting Furnaces	999
<i>J.J. Eksteen, and C. Cutler</i>	
Prototype Camera for Monitoring Aluminium Tapping	1009
<i>D. Death, L. Pollard, C. Rogers, P. Gwan, S. Maunder, F. Giurco, P. Herd, and A. Johnston</i>	
Local Temperature Control for Die Casting Processes.....	1015
<i>T. Yang, H. Hu, X. Chen, Y.-L. Chu, and P. Cheng</i>	
Modelling, Control and Optimisation of Chemistry and Viscosity of Copper Converter Slag.....	1023
<i>P. Tan, and P. Vix</i>	
Variance and Heterogeneity in Melt Samples from Industrial Ferro-Alloy Furnaces.....	1035
<i>J.J. Eksteen, E.L. Thyse, and M. Nkohla</i>	
Modelling and Control of Copper Isasmelt Furnace.....	1107
<i>P. Tan, and P. Vix</i>	

Separation Technology for Aqueous Processing

Session I

Bioleaching of Nickel Laterite Ore Using Halotolerant <i>Aspergillus Foetidus</i> Under Saline Conditions	1049
<i>V. Thangavelu, D. Ryan, A. Deepatana, and M. Valix</i>	
Ion-Exchange Recovery of Nickel and Cobalt from Metal-Organic Complexes Generated in Bioleaching of Low Grade Nickel Laterite Ores.....	1059
<i>A. Deepatana, and M. Valix</i>	
Kinetics of Limonite and Nontronite Ore Leaching by Fungi Metabolic Acids	1069
<i>A. Deepatana, J. Tang, and M. Valix</i>	
Semi-Batch Manganese Removal from a Zinc Leach Solution Using SO₂/O₂.	1079
<i>V. Menard, and G.P. Demopoulos</i>	
Study of Organic Phase Composition and Solvent Extractive Process for Purifying Nickel Chloride Solution with N₂₃₅	1089
<i>S. Chen, L. Wang, L. Zhang, and Y. Luo</i>	

[**Author Index**](#)

[**Subject Index**](#)