

THE 6th EUROPEAN METALLURGICAL CONFERENCE EMC 2011 (PROCEEDINGS REVIEW)

Stopić R. *Srećko*, IME Process Metallurgy and Metal
Recycling RWTH Aachen University, Aachen, Germany

FIELD: Materials Engineering, Chemical Technology

Abstract:

The GDMB Society for Mining, Metallurgy, Resource and Environmental Technology organized the 6th European Metallurgical Conference (EMC 2011) in Duesseldorf from June 26 to 29, 2011. The same venue hosted the most important international metallurgical trade fairs for metallurgy of iron and steel, new casting and thermochemical processes METEC, GIFA, THERMOPROCESS and NEWCAST. The previous European metallurgical conferences were organized by GDMB in Friedrichshafen (2001), Hanover (2003), Leipzig (2005), Duesseldorf (2007), Innsbruck (2009). The GDMB is a non-profit organization situated in Clausthal in Germany, which is related to combining science with the practical experience in metallurgy, mining, materials engineering, mineral processing, recycling and refining of metals, and manufacturing of semi- and finishing products. The European Metallurgical conference EMC is one of the most known conferences worldwide in the field of non-ferrous metallurgy and is attended regularly by the decision makers from the industry and universities. The scientific program contained 6 plenary lectures and more than 160 presentations from 40 countries in 5 parallel series. An extensive poster exhibition was held, during which the authors had an opportunity to introduce their posters to the entire plenum as a part of a brief presentation. The best poster from the Montan-University in Leoben, Austria, was awarded the € 500 "Poster Award EMC 2011". Not only were the most important European countries represented here, more than one third of the lecturers were from the non-European countries (Canada, Japan, China, USA, South Africa, Australia). The origin of the participants reflects the aim of the organizers: to make this conference a worldwide platform for the scientific exchange of experience and information. More than 400 participants from all over the world participated at this conference.

The scientific presentations of the conference are presented in five Proceedings: Vol. 1: Copper, General Pyrometallurgy, Vessel Integrity, Process Gas Treatment; Vol. 2: Lead and Zinc, Process Control, Process Modelling, Vol. 3: Light metals, General Hydrometallurgy, Precious Metals; Vol. 4: Process Metallurgy, Recycling, Waste Treatment and Prevention, Vol 5: Sustainable technologies, Sustainable of non-ferrous metals production, waste effluents Treatment and Biohydrometallurgical application. The plenary lectures will be published in the scientific journal "World of Metallurgy – ERZMETALL", which is published by the GDMB.

Key words: Nonferrous metallurgy, recycling, hydrometallurgy, metal, environmental protection.

Introduction

The colleagues from Berzelius Metall GmbH, Germany; Rubamin Ltd, India; University of British Columbia, Canada; CANMET-MMSL Canada, Bechtel Corp., USA; Tohoku University, Japan; Murdoch University, Facultad de Ingenieria UNAM, Mexico; Atlantic Copper S.A., Spain and Montan University of Leoben, Austria, participated in the work of the Scientific Advisory Board. The Co-sponsoring Societies are most important metallurgical associations: The Australasian Institute of Mining and Metallurgy, Australia; The Austrian Society for Metallurgy and Materials; Deutsches Kupferinstitut Berufsverband; the European Metallurgical Equipment Association; Instituto de Ingenieros de Minas de Chile; The Institute of Materials, Minerals, and Mining of Great Britain; Metallurgical Society of CIM, Canada; The Mining and Materials Processing Institute of Japan; The Nonferrous Metals Society of China; Norwegian Metallurgical Society; Society of Mining, Metallurgy and Exploration (USA), Verband der Aluminium Recycling- Industrie e.V. Verband Deutscher Maschinen und Anlagenbau e.V und Verband Deutscher Metallhändler. Between the 20 chosen chairmen two participants were from Serbia: Dr. Nikola Anastasijevic, Outotec GmbH and Dr. Srecko Stopic, RWTH Aachen University. Prof. Jakobi, president of the GDMB pointed out that EMC 2011 represents a signal to the world that the metallurgical industry is innovative and active and lives up to technical, ecological and economical challenges.

Plenary lectures

The plenary lectures of general interest for all conference participants were reported on Monday, June 27, 2011 and on Wednesday, June 29, 2011. The list of plenary lectures:

1. Wilkinson, Stephen, International Zinc Association; Belgium: **Zinc- A sustainable Metal**
2. Steinbach, Volker; Bundeswissenschaft für Geowissenschaften und Rohstoffe, Germany: **Deutsche Rohstoffagentur-DERA-Tasks and Goals of the German Mineral resources Agency**
3. Meier, Andreas, H.C. Starck GmbH, Germany: **Refractory Metals-Materials for Key Technologies and High Tech Applications**
4. Wilson, David, International Lead Associations, United Kingdom: **Lead-A Bright Future for the Grey Metal?**
5. Kirchner, Guenther, Organisation of the European Aluminium Recycling Industry ((OEA), Germany, **Aluminium Scrap as Vital Source of Aluminium Supply**
6. Van Camp; Maurits; Group Research and Development Umicore, Belgium, **Sustainability in Research- The Vision of Umicore**

The chosen lectures

Copper, General Pyrometallurgy, Vessel Integrity, Process Gas Treatment

Improving Copper Recovery from Production Slags by Advanced Stirring Methods

M. Zander, B. Friedrich – IME Process Metallurgy and Metal Recycling, RWTH Aachen University; M. Hoppe, J. Schmidl – Aurubis AG; R. Degel, J. Kleinschmidt – SMS Siemag AG

The intensive slag cleaning was reported in this study. Decreasing the heavy metal contents in slag generates a high quality mineral product [1]. Intensive slag cleaning leads to economic and ecological benefits. Lab-Scale Experiments were performed in order to study an influence of different stirring conditions on the copper inclusions settling. The results of the Lab-Scale Experiments have shown

- Significant degree of slag cleaning in all experiments
- By heating up the slag to a level of temperature above 1500 °C with moderate stirring, the copper content in the slag was decreased up to a maximum of 50%
- No significant differences in the degree of cleaning by the trials with no bath movement compared to the trials with a marginal bath movement were observed
- Strong turbulence in the melt by flushing gas inhibits the copper particle settling

Dissolution of copper and selenium from copper anode slimes

Y. Kilic, S. Timur, Technical University in Istanbul, Turkey

The recovery process of copper and selenium from copper anode slimes has been studied by employing hydrometallurgical methods under different reaction parameters. The optimal conditions for copper extraction (93.8 % Cu) were reported: temperature (80°C), a flow rate of 2 L/min oxygen, a stirring speed of 800 rpm, a solid-to-liquid ratio of 1:5, the concentration of 2 M sulphuric acid in time of 2 hours [2]. De-copperized anode slimes were treated by sodium hydroxide in order to dissolve selenium. The concentration of sodium hydroxide has a big influence on selenium extraction. The maximum recovery of 86.8 % selenium was detected in 4 M sodium hydroxide solution at a reaction temperature of 90°C with a used flow rate of 2l/min oxygen and stirring speed of 800 rpm in 3 hours.

Metallurgical fundamentals for an autothermic melting of WEEE in top blown rotary converter

S. Maurell Lopez, S. Gull, B. Friedrich, IME Process Metallurgy and Metal Recycling, RWTH Aachen University, Germany

M. Ayhan, M. Eschen, Aurubis AF, Hamburg, Germany

The New IME Recycling Research Center (IRRC) was built in last three years in the heart of Aachen at the RWTH Aachen University in Germany. This centre contains new electric arc furnace (EAF) and Top Blown Rotary Converter (TBRC). The recycling flow of used electric and electronic devices (EEE) is rapidly increasing in Western Europe because of the WEEE (waste of electronic and electric equipment)- directive 200/96/EC from 27.01.2003. Two different types of scrap are investigated in this work: Shredded circuit boards (called L1), Copper rich fraction of WEEE (called Y1). The off gas is cleaned by a state- of- the -art system which makes it possible to run this at the IME Process Metallurgy and Metal Recycling of the RWTH Aachen University. The experiments were performed at a temperature of 1250°C [3]. The material is inserted to the furnace with a maximum rate of 120 kg/h.

Lead and Zinc, Process Control, Process Modelling

Improvement of selectivity and kinetics in lead refining by controlled oxygen offer and employment of rotor injectors

B. Friedrich, A. Arnold, IME Process Metallurgy and Metal Recycling, RWTH Aachen University

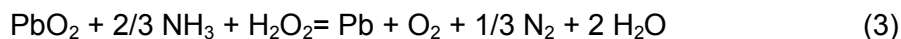
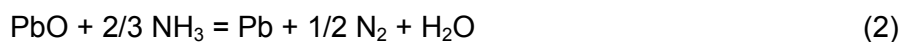
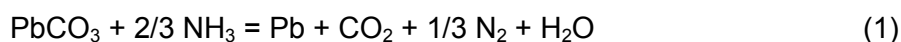
Lead is one of the oldest metals. Because of corrosion protection lead is broadly used in industry. Lead production involves several steps giving as a final product "Crude Lead". Removal of Sn, Sb, As by selective oxidation is a most present research subject. Oxidation kinetics of crude lead at 600°C to 617°C was investigated. The oxidation of the lead examined Pb-bullion has shown high selectivity when an oxygen supply in the gas mixture of 0.9 l/min was applied [4].

The FAST Pb Process- Electrowinning of Battery Paste of Oxidized Lead bearing materials

M. Maccagni, Engitec Technologies, Italy

A new electrochemical approach based on a chloride electrolyte and a high productivity flow cell was presented in order to point an importance of the recycling processes in lead metallurgy. In the last decade Lead

acid batteries are the most important raw materials for lead production. The problems related to recover lead from battery paste via electrowinning are such as: Lead sulphate has to be desulphurised to convert it to a soluble lead compound; prevention of PbO₂ deposition on anode; use of an insoluble anode with mechanical and chemical stability; and management of anode and cathode generated gases or mists. The FAST (Flakes Auto-Stripping Technology) Pb electrowinning Process improves an environmental impact making the process cheaper at the same time [5]. Total process reactions are shown below:



Generally, the FAST process regenerates the leaching reactant but consumes some NH₃ because of the chemical reaction following the anodic reaction. After a long test time in a pilot/bench plant, a demonstration plant was built by the Engitec company in Italy to demonstrate it fully.

Primary Lead Production with the QSL Process- an Ecological and Economical Advanced Technology

U. Meuer, H. Ambroz, Berzelius Stolberg GmbH, Germany

The benefits and energy savings in a new developed process BAYQIK process are described in this paper. This previously mentioned process was developed by the Berzelius Stolberg GmbH, Germany in cooperation with the company Bayer Technology Services. It enables the SO₂ content in the off-gas from QSL reactor to be raised up to 18 vol % while maintaining the gas stream constant at about 25,000 m³ /h [6]. Since 1990, BERZELIUS has been operating a double-catalysis sulphuric acid plant associated with its QSL reactor. The Queneau-Schuhmann-Lurgi (QSL) process treats all grades of lead concentrates, in a refractory-lined reactor into which oxygen and natural gas are blown through pipes at the bottom. The BAYQIK Process was developed in 2006 by applying state-of-the-art process simulation techniques. In 2007, the process was tested in a pilot reactor under real process conditions, integrated with sulphuric acid plant of BERZELIUS. By installing this new process in a bypass mode, it is possible to continue the operation of the existent double-catalyst plant without any modification related to the SO₂ emissions.

Light metals, General hydrometallurgy, Precious metals
Mechanism of Nanogold Formation by Ultrasonic Spray Pyrolysis

S. Stopic, R. Dittrich, B. Friedrich, IME Process Metallurgy and Metal Recycling, RWTH Aachen University

Gold nanoparticles were prepared by ultrasonic spray pyrolysis changing the reaction temperature and ultrasonic frequency. Two ultrasonic sources of 0.8 and 2.5 MHz, acted on the water solution of the HAuCl_4 forming aerosols with constant droplet sizes between 2.26 and 4.79 μm . The real size of droplets depends on the characteristics of the solution (surface tension, viscosity, and density) and the frequency of the ultrasound. In order to produce gold nanoparticles, a subsequent thermal decomposition of the aerosol droplets was performed in the hydrogen atmosphere between 260 °C and 500 °C [7].

SEM and EDS analysis have confirmed the presence of gold with different morphological forms (spherical, cylindrical and triangular), which is of big importance for some medical applications. The mechanism of synthesis of nanosized particles was proposed to form aerosol droplet via a solution precipitation and hydrogen reduction of the formed gold chloride and a subsequent sintering. Thermochemical investigations have confirmed a high value of negative Gibbs free energy for the hydrogen reduction of gold chloride up to 800 °C in contrast to the calculated positive values for the thermal decomposition of HAuCl_4 . Thermalgravimetric analysis of HAuCl_4 reported a decomposition of HAuCl_4 to AuCl_3 at 250 °C.

Nanosized Metallic Oxides produced by Ultrasonic Spray Pyrolysis

J. Bogovic, S. Stopic, B. Friedrich, IME Process Metallurgy and Metal Recycling, RWTH Aachen University, J. Schroeder, Institute for Technology in Karlsruhe

Synthesis of ideally spherical TiO_2 nanoparticles using an ultrasonic spray pyrolysis method was investigated in the nitrogen atmosphere at 800 °C from a new developed precursor solution. Droplet size distributions of precursor solutions were measured with the laser diffraction system (Malvern Spraytec). An examination of influence of the most critical process step (evaporation/precipitation) on the particle morphology was discussed in this work. In order to avoid the formation of non spherical particles, it is recommended to use a new reactor with slowly increasing temperature profile. A high evaporation rate leads to the formation of some destroyed non spherical particles [8].

Hydrometallurgical Processing of Li-ion battery scrap from Electric Vehicles

H. Wang, M. Vest, B. Friedrich, IME Process Metallurgy and Metal Recycling, RWTH Aachen University, Germany

In the scope of German national project the Hydrometallurgical Processing of Li-ion battery scrap from Electric Vehicles was studied. The main targets of this work were: a) Appropriate treatment of used batteries of electric vehicles, b) Development of an optimal hydrometallurgical process, c) Recovery of all valuable environmentally friendly materials (especially Li). The previous thermo-mechanical Treatment contained: 1) Disassembling (cells, steel casing, electric scrap, plastic), 2) Deactivation and electrolyte evaporation, and 3) Shredding and separation. The hydrometallurgical process contains three most important steps: leaching, purification of solution and precipitation of Li_2CO_3 . The recovery rate of lithium in the whole process amounts to 58% [9].

Process Metallurgy, Recycling, Waste treatment and Prevention

New perspectives in the Recycling of Dusts from Integrated Steel Mills

J. Antrekowitsch, Montanuniversität Leoben, Austria

This paper has reported the available metallurgical processes for the treatment of dusts from Integrated Steel Mills. New developments, first trials and product quality are considered. Regarding possible formations, three types of dusts were considered: Cupola furnace dusts, Electric Furnace Dusts EAF and Basic Oxygen Furnace Dusts BOF. The recycling rates for EAF and BOF amount to 45 % and 10 %, respectively. The most important target is an increase of recovery of zinc from solid residue. The BOF-dusts often contain a higher amount of metallic components (Zn, Fe) due to different gas systems [10]. The advantages and disadvantages of most frequently used process types (such as FASTMET, Oxycup, Primus) for recycling BOF dusts were reported. The first trials with combinations of the state-of-the-art methods as well as investigations with the use of a reducing iron bath as a central process part have shown the promising results.

Sulphur Control in Nickel-Based Superalloy Production

J. Morscheiser, L. Thönnessen, B. Friedrich, IME Process Metallurgy and Metal Recycling, RWTH Aachen University, Germany

Sulphur is a common impurity in raw materials and detrimental for the mechanical properties of nickel-based superalloys. The common method of desulphurization by NiCa and NiMg addition in vacuum induction melting is limited by several factors. The main target of this work is the

desulphurization during pressure electroslag remelting using active slags with different additives. Electroslag remelting is known to remove sulphur from iron- and nickel-based alloys. Regarding the removal of sulphur from the electrodes, $\text{CaF}_2\text{-CaO-CeO}_2$ seems to be the most efficient slag system [11]. The activity of the reagents in the fluxes will be optimized by further experiments and thermochemical calculations by means of Fac-tSage 6.2 developed in Germany.

Challenges in Titanium Recycling – Do We Need a Specification for Secondary Alloys?

B. Rotmann, B. Friedrich, C. Lochbichler, IME Process Metallurgy and Metal Recycling, RWTH Aachen University, Germany

The impacts of scrap compositions, scrap pretreatment and various refining operations on final titanium alloys compositions are considered in this study. Due to cost considerations, titanium alloys still play a minor role in mass applications. Conventional recycling focuses on classified, clean scrap. Low-grade scrap is downgraded to ferrotitanium alloys. Utilization of an inexpensive low-grade scrap fraction in a recycling process would result in a cost-competitive secondary titanium alloy. However, a new challenge arises with this proposed approach. Substitution of a titanium sponge by inexpensive low-grade scrap is possible in the IME recycling process [12]. It is concluded that a new, broader alloy specification of alloys is essential in order to open mass-application markets for the resulting secondary titanium alloys.

Sustainable technologies, Sustainable of non-ferrous metals production, Waste effluents Treatment and Biohydrometallurgical applications

Non-ferrous metals- Alternative Energy and Climate Change Implications

M. Ansari, Niitco GmbH, Germany

In this work the alternative energies, climate changes and economic implications were considered. It is reported that the use of renewable and less polluting fuels in the industry leads to the minimization of capital investment requirements and reduction of pollution. The climate change impacts are increasingly recognised by the financial community as a business risk issue with financial and environmental consequences [13]. Governments may play an important role by imposing and regulating stricter standard for energy efficiency. It is concluded that a better education and information are required for an efficient energy management.

Sustainable High Rate Biotechnology Applicable to Metallurgical Sulphuric Acid Plants

J. Huisman, M. Weghuis, Paques BV, The Netherlands

Sulphuric acid consumption is still increasing. Biological reduction and oxidation of sulphur compounds combined with desired selective metal recovery is a very well-known process. In the last 20 years this technology was characterized by compact residues and very high removal efficiencies and successfully applied by Paques BV under name Sulfatec™ at a zinc refinery in the Netherlands. In this study the successful implementations in different engineering systems at metal refineries were described. The background of biological sulphate removal and metal recovery with bio-based alternative for weak acid bleed treatment were reported. The weak acid bleed treatment at a lead smelter separates the dissolved metals in the acid and in a lead oxide dust into various fractions that can be reused effectively [14].

Application of Fluidized Beds in Metallurgy for better Energy Efficiency and Process Optimization

C. Klett, M. Missalla, J. Hammerschmidt, Outotec GmbH, Germany

Different fluidized bed types and configuration and new development were considered by the Company Outotec GmbH (former Lurgi Outokumpu, Germany). Fluidized beds are widely used in the processing of metal ores and concentrates and other fields in the nonferrous metallurgy and metallurgy of iron and steel. The most important characteristics of fluidized beds are: 1) Very low fuel consumption for an endothermic process such as calcination, 2) high utilization of energy in an exothermic process as roasting, 3) easy handling and transport of solids. A circulating Fluidized Bed CFB by the Outotec GmbH allows high throughputs and long residence time in small vessels with a very uniform temperature profile and good solid mixing. The optimization of fluidized bed processes was investigated in this work. The Outotec has reported about a Circulating Fluidized Bed CFB operating under very high gas velocities [15], especially for the treatment of fine particles.

Conclusion

The scientific presentations of the 6th European Metallurgical Conference were presented in five books (total of 1908 pages): Vol. 1: Copper, General Pyrometallurgy, Vessel Integrity, Process Gas Treatment; Vol. 2: Lead and Zinc, Process Control, Process Modelling, Vol. 3: Light metals, General

Hydrometallurgy, Precious Metals; Vol. 4: Process Metallurgy, Recycling, Waste Treatment and Prevention, Vol 5: Sustainable technologies, Sustainable of non-ferrous metals production, Waste effluents, Treatment and Biohydrometallurgical application. The 6th European Metallurgical Conference has confirmed that the metallurgical industry is highly innovative and has lived up to ecological and economical challenges with big success.

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ŠESTA EVROPSKA KONFERENCIJA O METALURGIJI EMC2011 (PRIKAZ ZBORNIKA RADOVA)

OBLAST: materijali, hemijske tehnologije

Sažetak:

Udruženje za rudarstvo, metalurgiju, sirovine i tehnologije za zaštitu životne sredine (GDMB), u periodu od 26. do 29. juna 2011. u Diseldorfu, organizovalo je Šestu evropsku konferenciju o metalurgiji EMC 2011. Na istom mestu su održani i sajmovi metalurgije u oblasti gvožđa i čelika, livenja i termohemijskih procesa METEC, GIFA, THERMOPROCESS i NEWCAST. Prethodne evropske konferencije o metalurgiji održane su u Fridrihshafenu (2001), Hanoveru (2003), Lajpcigu (2005), Diseldorfu (2007) i Insbruku 2009. GDMB je neprofitna organizacija sa sedištem u Klausthalu u Nemačkoj, koja se bavi povezivanjem nauke i praktičnih iskustava u metalurgiji, inženjerstvu materijala, procesiranju minerala, recikliranju, rafinaciji metala, proizvodnji poluproizvoda i završnih proizvoda.

Evropska konferencija o metalurgiji EMC jedna je od najpoznatijih konferencija širom sveta u oblasti obojene metalurgije i redovno je posećuju eminentni stručnjaci sa univerziteta i iz industrije. Naučni program je sadržao šest plenarnih predavanja i više od 160 prezentacija iz četrdeset zemalja u pet paralelnih sekcija. Održana je i dodatna poster-sekcija, gde su autori imali mogućnost da predstave svoje rezultate i održe po kratku prezentaciju. Najbolji poster sa Montan-Univerziteta u Leobenu u Austriji nagrađen je sa pet stotina evra. Sem autora iz Evrope, više od jedne trećine predavača bilo je iz zemalja izvan Evrope (Kanada, Japan, Kina, Amerika, Južna Afrika, Australija), što potvrđuje cilj organizatora da stvori jednu konferenciju sa širokom platfor-

mom za razmenu naučnih ideja i informacija i razvijanje poslovnih kontakata. Više od 400 učesnika učestvovalo je na ovoj konferenciji. Naučne prezentacije predstavljene su u pet različitih knjiga: prva knjiga: bakar, opšta pirometalurgija, integrisanost reaktora, prerada otpadnih gasova; druga knjiga: olovo i cink, procesna kontrola i modelovanje; treća knjiga: laki metali, opšta hidrometalurgija, plemeniti metali; četvrta knjiga: procesna metalurgija, recikliranje, tretiranje otpada i zaštita; peta knjiga: održive tehnologije, održiva proizvodnja obojenih metala, prerada otpadnih materijala i primene u bioprocesima i metalurgiji. Plenarna predavanja biće objavljena u naučnom časopisu: ERZMETALL Svet metalurgije – Rude i metali, koji izdaje udruženje GDMB:

Ključne reči: obojena metalurgija, recikliranje metala, hidrometalurgija, zaštita životne sredine.

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