ALUMINUM: RECYCLING AND CARBON / ENVIRONMENTAL FOOTPRINT

Aluminum: Recycling and Carbon/Environmental Footprint

DAVID S. WONG ^{1,4}, ANNE KVITHYLD,² and HONG PENG³

1.—Atmolite Consulting Pty Ltd, Gold Coast, QLD 4227, Australia. 2.—SINTEF Industry, Trondheim, Norway. 3.—School of Chemical Engineering, The University of Queensland, Brisbane, QLD 4072, Australia. 4.—e-mail: david.wong@atmolite.com

This special topic presents some of the latest technical developments and research into managing the aluminum industry's sustainability challenges. As covered by an informative panel discussion article in this month's issue of *JOM: The Magazine*, the magnitude of these challenges is significant. For instance, the International Aluminium Institute estimates that to meet the United Nations Sustainable Development Goals, with all its requirements for materials and energy resources (including renewables), primary aluminum production globally may need to increase another 25–30 million tons per year by 2050, on top of 2020s 65 million tons. At this scale, the industry's current challenges will continue to intensify, including the need for ethical and sustainable mining of bauxite with a demand of 500 million tons/year, large-scale solutions to manage the 250 million tons of bauxite residue/year from alumina refining, and the need for the industry—particularly smelters and alumina refineries—to shift toward low-carbon energy mixes if it is to make an impact on reducing greenhouse gas emissions.

Recycling has always been important and would reduce the intensity of sustainability challenges faced by primary production. This has recently drawn new attention because of increasing environmental awareness and as a key element of a circular economy. However, a circular economy will never take place without real (physical) solutions.

These vast sustainability challenges must be met by increased collaboration and sharing of knowledge, best practices, and technological advances across the industry, on a global scale, such as those described in the articles presented in this special

topic of JOM. The following seven articles focus on the recycling of aluminum (and its alloys) as well as mitigating the environmental ramifications of both primary and secondary aluminum production.

The first article, “Developing Guidance to Support Sustainable Spent Pot Lining (SPL) Management across the Aluminum Industry,” addresses the topic of spent pot lining, a fluoride and cyanide-containing hazardous, solid waste from the aluminum smelting process. Here, P. Nunez tracks the International Aluminium Institute's (IAI) development of an industry guidance for sustainable management of SPL, through the gathering of current best practices and commercially viable solutions from global aluminum producers. This provides a good case study as to how our international community can work together to collate and disseminate global best practices and technologies in addressing the industry's challenges.

On environmental issues in bauxite/non-bauxitic ore extraction and alumina production, we present four articles on this topic. Three papers are related to the utilization of non-bauxite resources (fly ash, coal gangue, and black aluminum dross) to produce various aluminas. The final article looks at turning diasporic ore into gamma-alumina and potash feed as fertilizer.

In the first of these articles, “Phase Transformation of Hercynite during Oxidative Roasting Process,” Li et al. extend their previous work on a new reduction roasting-alkali leaching process (RRALP) to conduct the efficient separation of silica and alumina in coal-based solid waste such as coal gangue, circulating fluidized-bed slag, and coal fly ash. In reduction roasting with hematite, full chemical disconnection of silica and alumina in aluminosilicates, including kaolinite, metakaolinite, and mullite, can be obtained by forming hercynite and free silica in the forms of quartz solid solution and cristobalite solid solution. The study here investigated the phase transformations of hercynite during oxidative roasting together with Bayer digestion of alumina.

David Wong, Anne Kvithyld, and Hong Peng are guest editors for the Aluminum Committee of TMS and also for the Recycling and Environmental Technologies Committee of TMS. They organized the special topic Aluminum: Recycling and Carbon/Environmental Footprint in this issue.

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In their article “Alumina and Silica Produced by Chlorination of Power Plant Fly Ash Treatment,” Kaplan et al. propose a process of chlorinating fly ash (using either chlorine gas or calcium chloride) to decompose mullite and produce alumina (α -Al₂O₃) and silica, with both high yield and purity, on a laboratory scale. To optimize input molar ratios and temperatures, the Gibbs energies for three groups of reactions of major fly ash components are also calculated for comparison.

Türk and co-workers in their article “Production of Alpha-Alumina from Black Aluminum Dross Using NaOH Leaching followed by Calcination” aimed at producing α -alumina particles from aluminum dross via leaching–precipitation–calcination processes. Their experimental findings indicate that the calcination temperature and stabilization time were critical for producing α -alumina particles rather than other polymorphs.

The final article on alumina is entitled, “Mechano-chemical Processing of Diaspore Sample for Extraction and Synthesis of Gamma-Alumina and Potash Values.” Here, Kumar et al. looked at developing a process route to utilize diaspore as a dual source of alumina and potash. To enhance the extractability of diaspore feed, the alkali thermal treatment involving conventional heating and microwave heating and mechanical activation was investigated as a pre-treatment step followed by acid leaching.

Moving to the topic of aluminum recycling, this topic contains two articles—one looking at how chips produced during machining of aluminum could be transformed into new products, the other looking at fundamentals in industrial practice where used beverage cans are compacted, submerged, and melted into a liquid bath of aluminum metal.

In the first paper, “Syntactic Aluminum Foam from Recycled Sawing Chips” by Thalmaier et al., aluminum sawing chips were used as the starting material for manufacturing matrix syntactic foams (lightweight porous composites). Spherical Ni-super alloy hollow particles were used to increase the density, followed by spark plasma sintering. The paper discusses compression strength, plateau stress, and densification strain, with all samples showing high energy absorption capabilities and good absorption efficiency.

In the second paper, “Environmental Footprint Dross Formation in Aluminum Melts During the Charging of Beverage Can Scrap Bales with Different Densities Using Various Thermal

Pretreatments,” Stiglich et al. present a thorough study showing that the char left from pyrolysis of metal coatings and the degree of surface oxidation both decrease the coalescence of molten scrap. This results in higher metal loss due to greater dross formation, with a higher metal fraction. The paper also demonstrates the importance of taking the organic content as a heating value into consideration along with the density of bales when remelting “non-clean” scrap.

The following papers being published under the topic of Aluminum: Recycling and Carbon/Environmental Footprint can be accessed via the October issue’s Table of Contents page at <https://link.springer.com/journal/11837/72/10/page/1>.

- “Developing Guidance to Support Sustainable Spent Pot Lining (SPL) Management across the Aluminium Industry” by Pernelle Nunez.
- “Phase Transformation of Hercynite during Oxidative Roasting Process” by Xiaobin Li, Hongyang Wang, Qiusheng Zhou, Tianguai Qi, Guihua Liu, and Zhihong Peng.
- “Alumina and Silica Produced by Chlorination of Power Plant Fly Ash Treatment” by Kaplan Valery, Dosmukhamedov Nurlan, Zholdasbay Erzhan, Daruesh Galamat, and Argyn Aidar.
- “Production of Alpha-Alumina from Black Aluminum Dross Using NaOH Leaching followed by Calcination” by Murat Türk, Mahmut Altiner, Soner Top, Serkan Karaca, and Chafia Boucekrit.
- “Mechano-chemical Processing of Diaspore Sample for Extraction and Synthesis of Gamma-Alumina and Potash Values” by Ashwini Kumar, Shrey Agrawal, and Nikhil Dhawan.
- “Syntactic Aluminum Foam from Recycled Sawing Chips” by Gyorgy Thalmaier, Niculina Argentina Sechel, and Ioan Vida-Simiti.
- “Environmental Footprint Dross Formation in Aluminum Melts During the Charging of Beverage Can Scrap Bales with Different Densities Using Various Thermal Pretreatments” by Jan Stiglich, Bernd Friedrich, and Marcel Rosefort.

CONFLICT OF INTEREST

The authors of this commentary declare that they have no conflict of interest.

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