Salt Cake Management at Secondary Aluminum Smelters: A Case Study of Best Practice

John N. Hryn
Argonne National Laboratory

TMS *2007 Annual Meeting; February 25-March 1, 2007 — Orlando, FL, USA*

Salt cake

- By product of aluminum recycling
  - Dross processing
- Potential value of components
  - Aluminum metal
    - Recoverable by crushing, screening, magnetics
  - Salt (flux)
    - Low value, wet processing
  - NMP (non-metallic product)
    - High value potential (alumina oxide)
- NMP Residuals are problematic
  - Unrecovered aluminum
  - Na/K-Cl/F
  - AlN (Aluminum nitride)

Salt Cake Recycling

- **Salt cake (salt slag)**
  - **Crushing/milling and screening (recover Al fractions)**
  - **Washing/leaching**
  - **Filtration (recover NMP for further treatment)**
  - **Crystallization (recover salt for use in flux)**
    - **Vapor recompression to minimize water use**

- **Total recycling**
  - **Aleris (Alumitech) – USA**
  - **ALSA – Germany, Canada (US ? – OH, KY, TN)**
  - **BEFESA – Spain, UK, (South America ?)**
  - **Others ?**

Hazardous characteristics of salt cake result from poor processing

- Reactivity
  - Water and air (pyrophoric)
- Health
  - Off-gas can be noxious, toxic
    - Primarily ammonia (NH3)
- Related to chemical composition
  - Residual aluminum content
  - Presence of aluminum nitride
  - Moisture
- All resulting from aluminum dross processing
- Improved processing can result in salt cake with non-hazardous characteristics (benign)

Consequences of poor practice in dross processing

- Poor quality of salt cake
  - Hazardous characteristics
  - Increased legal and environmental scrutiny
  - Difficult to place in the marketplace

- Recycling salt cake (wet processing)
  - Not energy efficient
    - More energy is used than recovered
  - Not environmentally efficient
    - Generate more waste compared to landfill
  - Not economic?
    - Driven by landfill costs and regulations

What is poor practice?

- **A-L-N**
  - **Presence of aluminum nitride (AlN)**
  - **Root of *ALL* major energy and environmental inefficiencies**
- **Presence of un-recovered aluminum**
  - **Poor business practice**
  - **Reactivity potential**

Effect of presence of aluminum nitride

- **Reactivity with water**
  - **AlN + H2O → Al2O3 + NH3**
  - **NH3 + H2O → NH4OH (pH increases)**
  - **High pH dissolves alumina film on un-recovered aluminum particle surface**
    - **Exposes aluminum surface to reaction**
  - **Al + H2O → Al2O3 + H2 (+ heat)**
  - **Hot H2 + O2 (air) → fire**
- **Worst case**
  - **Pyrophoric**
  - **Enhanced by processing Mg, Si, Zn containing alloys**
- **Best case**
  - **NH3 → noxious fumes**

Elimination of aluminum nitride - 1

- **Source:**
  - **NOx from air or oxygen-enriched-air burners**
    - **NOx much more reactive than N2 with aluminum**
- **Solution:**
  - **low NOx burner (good)**
  - **Oxy-fuel burner (better)**

Elimination of aluminum nitride - 2

- **Source:**
  - **N2 infiltration into furnace when tapping**
    - **More problematic with oxy-fuel burners**
      - **Higher surface temperatures**
- **Solution:**
  - **Two-door rotary furnace design**
    - **Better heat retention (economic)**
    - **Less nitrogen gas infiltration**

Elimination of aluminum nitride - 3

- **Source:**
  - **Aluminum processing (recycling)**
    - **melting furnaces**
      - **burners, air infiltration**
- **Solution:**
  - **Minimize dross formation**
    - **Keep aluminum surface quiescent**

Treatment of aluminum nitride

- Recycling salt cake NMP
  - Wet process (total recycling)
    - Must scrub aluminum nitride from NMP
      - Consumption of acid
      - NH4Cl or NH4SO4 product
  - Dry process for NMP
    - NMP must be calcined and air-reacted
      - Form aluminum oxide and NOx
      - Also reaction of residual aluminum
      - Also residual Cl/F vaporized
- Both processes are environmentally inefficient
  - More waste generated compared to landfill

Best environmental practice for salt cake management

- Rotary furnace
  - Oxy-fuel burners
  - Maximize aluminum recovery
  - Limit air infiltration
    - Two door design
- Dross cooling
  - limit thermite reaction
- Dry processing
  - Keep salt cake dry
  - Recover residual aluminum (crush, screen, magnetics)
- Disposal of salt and NMP residue in landfill
  - Lined (RCRA C standard)

Future of salt cake recycling

- **How much AlN can be tolerated in salt cake?**
  - **NONE**
  - **Processing to strip or react away AlN**
    - ***NOT* environmentally sound at any level**
  - **NMP product from "total" recycling must have *inconsequential* amount of AlN**
    - **Determined by market**
    - **Market cannot diminish value of NMP because of "hazardous" character**

- **Total recycling of salt cake will be environmentally acceptable only when aluminum processors and dross processors limit (eliminate) aluminum nitride formation during processing**

Acknowledgements

- **Co-author:**
  - **Miguel Lizaur, Iberica de Aleaciones Ligeras, S.L. (IDALSA), Pradilla de Ebro (Zaragoza), Spain**

- **Funding:**
  - **US DOE, Office of Energy Efficiency and Renewable Energy, Industrial Technologies Program**

- **Companies:**
  - **IDALSA, Aleris (IMCO and Alumitech), Secat**