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The Energy and Environmental Implications of Recovering Salt Flux from Salt Slag Generated by the Aluminum Industry

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Salt slag (Salt cake)

- By-product of aluminum recycling
  - Dross, post-consumer scrap, UBC, prime scrap
- Salt cake composition: source material and recycling practice dependent
  - Aluminum metal (finely distributed) (4-8%)
  - Salt (flux -- NaCl, KCl, Fluoride) (25-45%)
  - NMP (non-metallic product) (50-70%)
    - Oxides (mainly alumina and spinel– $MgAl_2O_4$)
    - Unrecovered aluminum
    - Fluorides
    - AlN (Aluminum nitride)
    - Other oxides (Fe, Si, Zn..), carbides…

Why recycle salt cake?

- **Recover residual aluminum (4-8%)**
  - **Economic and environmental benefit**
  - **Recover more that half of residual Al**
    - **>50% Al energy content (break-even at 2-3% Al)**
- **Perceived environmental hazard related to salt cake composition**
  - **Reactive, pyrophoric**
  - **Noxious ammonia odor**
  - **Leachable chloride content**

Hazardous characteristics of salt cake

- **Reactive in the presence of moisture**
  - **Related to residual Al and AlN content**
- **Aluminum nitride reacts with moisture to form ammonia fumes**
  - **Noxious odor**
- **Leachable chlorides**
  - **Potential contamination of local ground water – aquifers**
  - **Can be controlled with disposal practice**

Presence of aluminum nitride in salt cake

- **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 → Al(OH)3 + H2 (+ heat)**
  - **Hot H2 + O2 (air) + combustibles → fire**

Salt Cake Processing Descriptions

- Dry processing
  - Crushing/screening
  - Recovery of aluminum by eddy-current magnetic separation
  - Disposal of salt/NMP in controlled landfill
- Wet processing
  - Aluminum recovery (crushing, digesting, screening, and washing)
  - Salt recovery (sometimes), with evaporator/crystallizer and vapor recompression
  - NMP recovery (filtration, thickening, drying)
    - Further processing is necessary (calcining)

Salt Cake Processing Locations

- **No processing**
  - **Responsible disposal: many places**
  - **Irresponsible disposal: many places**
- **Dry processing**
  - **USA, Spain**
- **Wet processing**
  - **USA, Germany, Canada, Spain, UK, Norway, Italy, Brazil**

Wet process justification

- **Perception:**
  - **Salt cake is hazardous**
  - **Disposal into landfill is bad**
- **Perceived solution:**
  - **Total recycling**
    - **All salt cake components recycled – really?**
    - **Is this the best option? For environment?**

Assumptions: Dry vs Wet Processing

- **Dry processing (on-site)**
  - **Aluminum recovered (magnetic separation)**
  - **Salt/NMP disposal (controlled landfill)**
- **Wet processing (central facility)**
  - **Aluminum, salt, NMP all recovered**
    - **Incorrrect assumption!**
    - **Aluminum already recovered by dry process**
- **Salt and NMP recovery alone must entirely justify wet process**

Wet Process Negatives: Energy and Environment

- Excessive energy for transportation to and from central facility
- Recovery of salt and NMP not energy efficient
  - Less energy to produce similar products (salt, NMP) from raw materials
- Salt & NMP recovery consumes water resources
  - Need chemicals for water purification, gas handling
- NMP requires further energy for processing at high temperature (>1200C) to convert NMP to saleable products for cement industry
  - Residual Al and chlorine removed during calcining
  - Sodium, potassium, and fluoride can still be an issue

Negatives of "Total Recycling" solution

- Excessive energy use
- Excessive water use
- Excessive chemical use
- Excessive CO2 emissions (energy)
- Depletion of resources
  - energy, water
- Not Total Recycling

Better environmental approach

- **Change processing conditions so that the hazardous characteristics of salt cake are minimized or eliminated (no longer “hazardous”)**
  - **Maximize aluminum recovery**
  - **Minimize aluminum nitride formation**
  - **Minimize salt flux (chloride) use**

Preferred Processing

- **Maximize Al recovery in furnace**
  - **Improve RF or TRF operation**
- **Optimize magnetic separation for maximum recovery of Al from salt/NMP**
- **Minimize AlN formation in furnaces**
  - **Minimize NOx in burners**
    - **NOx and Al = alumina and AlN**
- **Minimize salt use with good practice**

Conclusions 1/4

1. **Dry processing with maximized Al recovery – best energy and environmental option for salt cake processing**

Conclusions 2/4

2. **Analysis of Wet Processing**
   - **Cannot use aluminum recovery to justify process**
   - **Process is not justified on energy and environmental grounds for salt and NMP recovery for re-use, re-sale**

Conclusions 3/4

3. **Good Al recycling practice and salt cake processing practice decreases the hazardous characteristics of salt cake**
   - **Maximize Al**
   - **Minimize AlN**
   - **Minimize salt (chloride) use**

Conclusions 4/4

4. **Responsible disposal of salt and NMP fractions of salt cake in a controlled landfill -- the best environmental solution to salt cake processing TODAY**

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