A New Salt Slag/Black Dross Recycling Process

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Aluminium Dross and Salt Slag

- Both waste streams from aluminium/dross recycling
- > 2 mtpy of aluminium drosses per year globally
- > 2 mtpy of salt slags generated in Europe

- Both of these waste streams can be totally circular as they contain a lot of Al and also the residual oxides can be re-used.
GOOD DROSS MANAGEMENT

STEP 1
Minimise Dross in Furnace
50-70% Al in resulting dross*

STEP 2
Recover 10-20% of this Al and capture remaining Al in skull
40-50% Al in resulting dross skull*

STEP 3
Recover 40-60% of this Al in rotary salt furnace
5-10% Al in resulting slag*

STEP 4
Recover 5-10% Al, and also salts and NMP (oxides) for re-use

* By weight
Issues with salt slag

• Typical cooling times are 24 to 36 hours before shipping
• Requires large area for cooling
  – special heat resistant concrete floors,
  – or racking systems
  – Many dross/slag bins
• Aluminium in the slag can burn off/develop AlN’s
• Dealing with the environmental issues for transportation
• Temperature for shipping < 100°C
• Logistics, distances and costs for transportation to recycling centres
• Cost of recycling
Salt Slag Cooling – Typical

- Typical cooling times typically 36 hours.
Salt Slag Cooling with Slag Pressing

Cooling time after 15 min press cycle now 4 hours
Typical solid components in dross

- Aluminium
- Alumina Oxide (Al$_2$O$_3$)
- Spinels (MgO.Al$_2$O$_3$)
- Aluminium Nitride (2AlN)
- Aluminium Carbides
- Aluminium Sulphites (trace)
- Aluminium Phosphates (trace)
Possible Gaseous Components of Dross are:

- $\text{NH}_3$ (Ammonia)
- $\text{H}_2\text{S}$ (Hydrogen Sulphide)
- $\text{H}_2$ (Hydrogen)
- $\text{SO}_2$ (Sulphur Dioxide)
- $\text{CO}_2$ (Carbon Dioxide)
- $\text{CH}_4$ (Methane)
- $\text{NH}_4\text{OH}$ (Ammonium) Hydroxide
- Phosphine
- Phosgene (possibly)

So it's not just the salt slag you have to consider!
Aluminium Metal compound reactions with water

• $2\text{AlN} + 3\text{H}_2\text{O} \rightarrow 2\text{NH}_3 + \text{Al}_2\text{O}_3$ (Ammonia)

• $2\text{Al} + 3\text{H}_2\text{O} \rightarrow 3\text{H}_2 + \text{Al}_2\text{O}_3$ (Hydrogen)

• $\text{Al}_4\text{C}_3 + 6\text{H}_2\text{O} \rightarrow 3\text{CH}_4 + 2\text{Al}_2\text{O}_3$ (Methane)

• $\text{Al}_2\text{S}_3 + 3\text{H}_2\text{O} \rightarrow 3\text{H}_2\text{S} + \text{Al}_2\text{O}_3$ (Hydrogen Sulphide)
Project – ALUSALT – Timeline

• New ALTEK/EU development project initiated in 2011
• Objective ‘small and medium scale’ local salt recycling at salt slag generation source
• Small capacity pilot plant was operational by late 2014 at ALTEK – 200kg/day
• Funding for full scale demonstration unit secured in Q3 2015
• Design of full scale system completed – Q1 2016
• Installation started end Q1 2017
• Operational by end Q2 2017
ALUSALT - Key Principles

- To provide a cost effective solution for recycling salt slag **at source of generation**
  - From 3000tpy to 30,000tpy
- Benefits:
  - Massive reduction in transportation of salt slag around Europe
    - Fuel cost savings
    - Environmental issues reduced
    - CO$_2$ footprint reduction
  - Re-use of own salt (avoids ‘other things’ being in it)
  - Re-use of own aluminium
  - Provide security and viability of recycling operation
  - Re-use of energy released from salt slag at plant
Front end crushing

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<td>Overhead Magnetic Separator</td>
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<td>17</td>
<td>Product Bin</td>
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Salt Slag Analysis – Pre-Treatment

ANALYSIS OF PRE-PROCESSED MATERIAL (MIXED SCRAP AND DROSS)
Crushing – Stage 1

Input Material - 300mm x 300mm maximum size
Crushing Stage 1 - Output
Crushing – Stage 2

Input Material - NMP 3mm to 50mm
ECS Stage 2

Input Material - 3mm to 50mm
Aluminium recovered
(Pressed vs Unpressed)
Crushing Stage 2

> 3mm
ECS – Aluminium recovery

Stage 2

Stage 3
Final Crushing - Stage 3 –
Pre-Wet stage

< 3mm
NMP – Stage 1 Filtering

Input Material - NMP > 3mm
Dried NMP
NMP – Analysis

ANALYSIS OF POST PROCESSED MATERIAL (MIXED SCRAP AND DROSS)
Inert NMP
Target end use of NMP

- Steel Industry as a Synthetic Slag ($\text{Al}_2\text{O}_3$)
- Rock Wool
- Cement Industry
- Bricks/Tiles (additive)
- Sandblasting
- Refractory
- Ceramics
- Flux
- Miscellaneous
ALUSALT - Salt

- Moisture < 0.3%
- Yield >98%
- Same consistency as input salt ratio
Plant Design
Plant Design
Plant Design
Plant Design
Plant Construction
### Closing the loop on Dross and Slag

- **Recover the Aluminium**
  - 1000kg of dross (containing 70% Al) → 700kg Al
  - Press to get 10-20% of the Al in drain → 105kg Al
  - Secondary recover 50-70% of the Al → 327kg Al
  - Recover 5-10% Al from the salt slag → 25kg Al

- **Re-use the NMP (oxides) – end markets**
- **Re-use the Salt – closed loop**

- **Overall recovery** *
  - 68%(low) 83%(high)

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* From available aluminium in the dross
Summary

1. Efficient dross management in cast house exists
2. Efficient dross recycling systems already exist (Salt Furnaces)
3. Mini salt slag plant solution innovation the next step
   - Process proven on pilot scale plant Q1 2015 – Q2 2016
   - Tested wide variety of salt slags from differing sources
   - Adaption and modifications to design completed allowing scale up to start
   - Full scale demonstration plant design completed Q1 2016
   - Procurement completed end 2016
   - Installation started Q1 2017
   - Operating plant by end Q2 2017

To allow complete Al recovery from waste streams at place of generation.