Reduce Melt Loss, Recover Aluminium and Re-use the by-products: An Optimised approach to Total Dross Management

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Agenda

• The significance of DROSS
• Dross management – in the furnace
• Dross Cooling Technologies
• Secondary Dross Processing
• Dealing with the residues
• Summary
The reality of Dross!

- Looked upon as the unfortunate evil of the industry
- Often, dross is at the bottom of the cast house priority list *(LOW PERCEIVED VALUE)*
- The quality and amount of dross generated can be a good indicator of efficiency in the cast house
Dross Management

- Dross can account for 5% of a facilities total production
- Dross can contain up to 80% of aluminum
- 1% of aluminum can be lost per minute through oxidation
- The treatment of the dross after skimming is the single most important factor influencing the metal content and the value of the dross
Financial Impact of Melt Loss/Dross

- More than 1.5 million tpy of dross is produced from aluminium cast houses as a consequence of melt loss.
- This equates to more than US$ 1.6 Billion in available value in aluminium* within the Dross!!

* Assuming 60% Al in dross and LME @ $1800/tonne
Cast House and Furnace
Melt Loss and DROSS
Note 1. Taken from a study of Australasian smelter cast houses by Clarke
Furnace Melt Loss – Smelter cast house

* Assumes a typical casting furnace in smelter cast house – ‘non re-melt’

Scrap would be a much larger contributor in a re-melt furnace.
Managing Furnace Practices

Step 1
Furnace Melt Loss - Best Practice

- Implementing technology and processes to minimise melt loss and effectively deal with DROSS can move you towards industry BEST PRACTICE...

- Best Practice – Less than 0.6% melt loss*

* Siphoning, 99.9% Al (no alloying), no scrap additions – primary operation
Furnace Melt Loss Contributors

- Liquid metal addition (from pot lines)
- Scrap addition and method of charging
- Burner settings and control
- Alloying process
- Flux additions
- Furnace stirring techniques
- Skimming practice
- Furnace bath temperature control
Melt Loss – Metal Addition

- Pouring and cascading develops $\text{Al}_2\text{O}_3$
- Siphoning can reduce melt loss by $> 70$

... A Good Practice
Melt Loss - Furnace Charging

- Most melt loss from scrap is developed when exposed to burners
- Minimise door open time
- Method of charging
Melt Loss - Scrap Type and Quality
Melt Loss - Light Gauge

- Need to submerge/melt quickly
- Keep away from the burners
- Use vortex type charging systems if possible for light gauge scraps

....A Good Practice
Melt Loss – Burner control

- Several melt loss contributors:
  - $O_2$ mix too rich
  - Direct impingement on the surface/scrap
  - Overheating/wicking of the Al

Also bad burners generate AlN which causes challenges later!
Melt Loss - Alloying

- How is the alloy added?
- Need to minimise door opening times
- Need to add alloys to minimise alloy losses
Melt Loss - Furnace Skimming

- Skim at the right time
- Minimise Al removal in the dross
- Leave on sill to allow Al to drain back
- Ensure consistency
- Minimise door open time
- Also minimise wall, sill damage etc.
- Robotic/Automatic skimming

.....A Good Practice
Managing Bath Surface Temperature
The Temperature of the metal is the single most controllable factor that determines dross generation in a furnace.
Furnace Heat Transfer

\[ Q_{\text{rad total}} = Q_{\text{rad gas}} + Q_{\text{rad wall}} \]

\[ Q_{\text{rad total}} = Q_{\text{bath absorbed}} + Q_{\text{bath reflected}} \]

Conduction + convection
Bath surface temperature

The Temperature of the metal is the single most controllable factor that determines dross generation in a furnace.

Temperature Values:
- 648°C
- 704°C
- 760°C
- 815°C

782°C
Furnace Stirring

- If high alloy (such as 5xxx etc.) OR
- Scrap as part of charge

- Stirring will:
  - Reduce dross (10 to 30%)
  - Increase productivity (10 to 20%)
  - Improve quality
  - Reduce energy

.....A Good Practice
Managing Dross after the Furnace

STEP 2
Two extremes !!

1% Al loss per minute

Heavily thermiting
Initial Step

SKIM

COOL

or

HOT PROCESS

LOGISTICS

TIME

LABOUR

ENVIRONMENT
Capture the value of Al

1% Al loss per minute  
Capture the value immediately

Easier handling  
Maximise “in house” aluminium drain
Post Furnace Dross Process - Which way?

- **Cooling**
  - Disconnects the dross generation from secondary recovery and gives TIME
  - Rapid sealing of aluminium
  - Easier logistics
  - Less environmental impact

- **Hot Processing**
  - Logistics very important
  - Continued Al burning if dross bins left waiting
  - Difficult logistics if too many furnaces
  - Lower overall Al recovery
Prevalent Dross Cooling Technologies

Inert Gas Dross Cooler

Dross Press
Dross Press

• Developed by ALTEK in the mid 1990’s
• Consists of a steel frame, hydraulic unit, press head and dross pan set
• Dross is skimmed into the dross pans
• Pan is transferred into the dross press
• Head is slowly lowered into the dross squeezing trapped metal into the sow mold below
• Head not only extracts metal but also cools the dross preventing further oxidation
Consolidation of Aluminum Particles

- Consolidates the fine particles remaining within the dross
- Migrate to the outside surface of the dross in plates
- These plates or skin encapsulates the dross preventing further oxidation of dust and fuming
- Significantly improves recovery by 5 – 10%
Testing Procedure

- Dross was skimmed simultaneously into the pans supplied for both technologies.
- Inert Gas Cooler pan(s) were placed in the hood(s) and left to cool under the inert atmosphere. Simultaneously, the Dross Press pan(s) were processed through the dross press system.
- Once processed through each technology, every dross pan was weighed to establish the weight of dross as well as the amount of metal captured in the drain pan below.
- When cooled, the dross from each technology was placed in separate dross bunkers.
- The dross was shipped to a separate facility where it was processed in a Tilting Rotary Furnace.
- The secondary facility was aware that a comparative study was being conducted and the loads of dross were segregated accordingly.
In-house recovery – 16 weeks data

- In house recovery is expressed as a percentage of dross skimmed
- Data collated per week
- Dross Press consistently provides a higher recovery than the Inert Gas Cooler

![In-House % Recovery by week graph]

0.00% 5.00% 10.00% 15.00% 20.00% 25.00%

Week1 Week2 Week3 Week4 Week5 Week6 Week7 Week8 Week9 Week10 Week11 Week12 Week13 Week14 Week15 Week16

Cooler Dross Press
In-house recovery

- Over the trial period, higher in-house recovery with press technology

![In-House % Recovery Graph]

- Cooler: 8.77%
- Dross Press: 17.76%
Secondary recovery – 16 weeks data

Similar results on the secondary recovery from a Tilt Type Rotary Salt Furnace
Total Recovery - 16 weeks data

- Higher combined recovery ~ 3% from press + Tilting Rotary Salt Furnace
The Secondary Dross Process

STEP 3
Secondary Dross Processing

• OPTIONS
  – Tilting Rotary Salt Furnace
  – Mechanical crushing/separation

• People say ‘remove the salt’ by not using a rotary furnace ....BUT there is more than just the salt to consider

• You need to consider all the constituents in the dross!
The Dross Processor

Dross Skulls need to be recycled in a Tilt Type Rotary Furnace

ALTEK 16 MT Tilt Type Rotary Furnace

Can crush/grind to increase the metallic content (reduce salt/increase efficiency)
Still the most effective way to process dross:
- Obtain the highest metal yield
- Low salt solutions
- Lowest emissions
- Smallest footprint
- Most flexible operation

BUT requires further processing of the salt slag
Environmental Issues - Why no landfill?

- Main problems:
  - Leachability:
    - Toxic metal ions into ground water
  - Reactivity with water or moisture:
    - Gaseous emissions of NH$_3$, CH$_4$, PH$_3$, H$_2$S
  - With temperature and pressure Cyanides also possible (due to Al$_4$C$_3$)
  - Aluminium Phosphide and Sulphides
Typical solid components in dross

- Aluminium
- Alumina Oxide ($\text{Al}_2\text{O}_3$)
- Spinels ($\text{MgO}.\text{Al}_2\text{O}_3$)
- 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)
The NMP and Salt Recovery

STEP 4
Project - ALUSALT

- New development project initiated in 2011
- Objective local salt recycling at salt slag generation source
- Demonstration small capacity pilot plant to be operational Q1 2015
ALUSALT - Key Principles

- To provide a cost effective solution for recycling salt slag at source of generation
  - From 3000tpy to 25,000tpy
- Benefits:
  - Massive reduction in transportation of salt slag around Europe
    - Fuel cost savings
    - Environmental issues reduced
    - CO₂ 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
ALUSALT – Leaching Results

Infeed – 1mm salt slag

Leaching vessel

Pilot Plant – 1 T/Day

Filtered NMP Cake
ALUSALT - Salt

- Moisture < 0.3%
- Crystal sizes up to 2.5mm
- Also looking at compaction of salt
ALUSALT – The next steps

• Trials with variety of salt slag to measure all parameters and optimise designs have started
• Currently working on scale-up designs
• Scale up plant operating by Q2 2016
• Develop partnerships with aluminium operations to implement the technology
NMP (Non Metallic Particulate)

• The key is to get the NMP ‘inert’
• Once safe it can then be used and transported safely
• In Europe this is undertaken by salt wash systems (large Salt Reclamation plants) to ensure the NMP is safe for sale to down stream applications - and will not release the gaseous emissions when wet.
End uses of NMP

- Steel Industry as a Synthetic Slag ($\text{Al}_2\text{O}_3$)
- Cement Industry
- Bricks/Tiles (additive)
- Sandblasting
- Refractory
- Flux
- Miscellaneous
The Economics Of DROSS Management
TOTAL DROSS MANAGEMENT

STEP 1: Minimise Dross in Furnace

STEP 2: Recover 10-20% Al and capture remaining Al

STEP 3: Recover 40-60% Al

STEP 4: Recover 5-10% Al, salts and NMP for re-use
## Mass Balance example (6xxx) dross

<table>
<thead>
<tr>
<th>Description</th>
<th>Mass 1</th>
<th>Mass 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000kg of dross (containing 70% Al)</td>
<td>700kg</td>
<td>700kg</td>
</tr>
<tr>
<td>Press to get 10-20% of the Al in drain</td>
<td>105kg</td>
<td>140kg</td>
</tr>
<tr>
<td>Secondary recover 50-70% of the Al</td>
<td>327kg</td>
<td>392kg</td>
</tr>
<tr>
<td>Recover 5-10% Al from the salt slag</td>
<td>25kg</td>
<td>50kg</td>
</tr>
<tr>
<td>Re-use the NMP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Re-use the Salt</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Overall recovery</strong> *</td>
<td>68%(low)</td>
<td>83%(high)</td>
</tr>
</tbody>
</table>

* From available aluminium in the dross
Dross Management - Summary

• It starts in the furnace – furnace practices in the furnaces and **rapid attention** after skimming
• Rapid cooling to capture Al
• Logistics and secondary processing
• It is possible to manage residues and slag for re-use
• It is possible to recover 60 to 80% of the available aluminium

**This is worth between $960m and $1280m to global aluminium industry**