Secondary zinc as part of the supply chain and the rise of EAF dust recycling

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Presentation outline

• Introduction
• Zinc Recycling - Background
• EAF Steel Production
• EAF Dust
• EAF Dust Processing – Technology, Plants
• Waelz Zinc Oxide / Solvent Extraction
• Regulations
• Summary and Future developments
ILZSG Overview

- Intergovernmental organization set up within the UN system
- Significant level of industry representation
- Established by UN in 1959 in New York
- Moved to London in 1977
- From start of 2006 ILZSG, ICSG & INSG co-located in Lisbon, Portugal
ILZSG Membership

- Membership open to any country involved in lead and/or zinc production, usage, or trade
- 30 members (>85% of global lead/zinc industry):

Australia  Germany  Morocco  Serbia
Belgium  India  Namibia  Sweden
Brazil  Iran  Netherlands  Thailand
Bulgaria  Ireland  Norway  Turkey
Canada  Italy  Peru  United States
China  Japan  Poland  European Community
France  Mexico
ILZSG Overview – Work of the Group

• Facilitate Co-operation Between Government and Industry
  ✓ Twice yearly meetings
  ✓ Special conferences/seminars

• Conduct In-depth Research into Other Issues of Interest or Concern to Members
  ✓ Economic developments
  ✓ Environmental legislation

• Promote Transparency in the Lead and Zinc Markets
  ✓ Closely monitor production, consumption, prices, stocks, trade flows and market balances
  ✓ Reports and directories
Zinc Recycling - Background

• International Zinc Association (IZA) estimates that secondary zinc represents about 25% of total refined output

• This is zinc’s “Recycled Content” and accounts solely for the fraction of recycled zinc contained in the overall refined metal production, by the use of scrap as an input to the refining process (in addition to concentrates)

• According to IZA and considering the end of life efficiencies, about 60% of the zinc contained in old scrap coming to end of life is ultimately recycled

• Some of the recycling activity does not bring zinc back to the refining chain. For example most of the brass and die cast alloys are re-melted and thus recycled as brass and die cast alloys rather than refined zinc
Zinc Recycling - Background

- Regardless of the way it’s assessed, zinc recycling is a beneficial supplement to primary metal production because it reduces emissions, energy use and solid wastes, bringing social, environmental and economic benefits.
- It helps the refining industry to be less dependent on the supply of zinc concentrates by the mining sector, which could reduce risks associated with concentrate price’s fluctuations, supply disruptions, etc.
- Zinc can be recycled without damaging its metallurgical characteristics.
- Zinc is a valuable commodity: by allowing the recovery of metal contained in products at end of life – which would be wasted otherwise – the recycling activity avoids economic loss.
Zinc recovery from EAF Dust

Growing rates of zinc recovery from products at end of life show that the industry has been actively targeting new and/or more efficient technologies and methods to improve results.

In recent years, one of the most dynamic areas has been the zinc recovery from electric arc furnace (EAF) dust.

ILZSG has recently published a 60 page report on this topic:

Zinc Recovery Electric Arc Furnace (EAF) Dust – Worldwide Survey
Zinc Recovery Electric Arc Furnace (EAF) Dust
Worldwide Survey

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A report prepared by Larry Southerland, P.E., for the
International Lead and Zinc Study Group
January 2015
Zinc recovery from EAF Dust – Steel Scrap

- Today more than 50% of zinc is used in galvanizing.
- The steel scrap available throughout the world includes steel that had been coated with zinc.
- Some industries, such as automotive and construction are becoming increasingly more intensive in the use of galvanized steel.

Galvanized steel’s share in total steel scrap is rising.
Zinc recovery from EAF Dust – EAF Steel production

• Electric Arc Furnace production of steel is fed 100% by steel scrap

• Almost 30% of the 1.56 billion tons of steel generated in 2014 is secondary steel produced in Electric Arc Furnaces

• The recycling of steel is less energy intensive and it’s being stimulated by increasing environmental regulations

• EAF Steel production generates a zinc-rich dust, the EAF Dust

• Around 15 to 22kg of zinc-rich dust is generated per ton of steel
Zinc recovery from EAF Dust – EAF Dust

- The zinc content of EAF dust’s from around the world show a wide degree of variation, reflecting the composition of the scrap melted in the furnaces.

- Studies cited in ILZSG’s report show Zn contents of 31%, 28.5%, 29.1%, 8%, 18%, 18.9% ...

- In the US, analysis of dust generated in 11 mills showed an average 25% of zinc content (max: 41.8% / min:17.3%)

- A variety of residual metals (such as Cr, Mn, Ni and Cu) can also be found in the dusts, which reflect the different kinds of steel alloys being produced in the electric furnace.
Zinc recovery from EAF Dust – EAF Dust in China

- China is by far the world’s biggest producer of steel (around 50%) but generates only 14% of the EAF dust.
- Availability of steel scrap is increasing, so it is foreseen that EAF secondary steel production will intensify in the future.
- Chinese EAF dust zinc content lies well below the world’s average. Analysis of dust generated in 7 mills showed an average 9% of zinc content (max:18.9% / min:2.6%).
- Galvanized steel’s proportion in total steel scrap used in China is low, but industries such as automotive are becoming increasingly more intensive in the use of galvanized steel.
- This will raise zinc content in upcoming steel scrap making China the most likely country to offer new opportunities for dust processing and recycling.
Zinc recovery from EAF Dust – EAF Dust

• Assuming an average (conservative) of 20% zinc content in the EAF dust
  • Overall around 8.5 million tonnes (mt) of dust containing 1.7mt of zinc is generated
    ✓ 4.0mt of dust containing 0.8mt of zinc is recycled
    ✓ 4.5mt of dust containing 0.9mt of zinc is not recycled (most of it is land filled)

• Improvements in efficiency have allowed ever lower zinc grades of dust (below 15%) to be processed

• Within the next five years new electric furnace steel production could rise by at least 50 million mt per year, which would produce roughly 1 mt of new dust
Zinc recovery from EAF Dust – Dust Processing

• EAF dust is considered a hazardous waste, which means how the dust is treated or otherwise disposed is closely regulated.

• Increasing regulations and higher landfill costs (together with rise in zinc prices) became an incentive to process EAF dust.

• It has long been recognized as a potential source of recycled zinc, but the technical problems of economically extracting the zinc have presented challenges.
Zinc recovery from EAF Dust – Technology

- Under the procedures spelled out in the 1980 regulations, the US EPA (Environmental Protection Agency) had to designate a specific technology to treat EAF dust.
- The reference process was the **Waelz kiln**
- Waelz kilns are most economical when operating on a large scale (several mills supplying dust), and much of the new technology development was to provide steel mills with the option of inhouse processing for a single mill.
- However, that effort overall has not been successful

**Waelz kilns remain the predominant method of processing dust, with over 85% of the market**
Zinc recovery from EAF Dust – Technology

- Alternative technologies include:
  - Rotary hearth furnace
  - Hydrometallurgical processes
  - Mitsui Furnace
  - Electrothermal Furnace
  - Daido Furnace
  - Flame Reactor
  - Primus process
  - Scan Arc process
  - PIZO process
  - ERSF process

- Compared to the alternatives, the Waelz kiln is a proven technology with lower energy consumption. It may see further improvements, but currently there do not appear to be any new processes that can exceed its efficiency, reliability, economics or regulatory compliance.
Zinc recovery from EAF Dust – Dust Processing Plants

- Japan has 7 dust processors with an estimated combined processing capacity of over 400 thousand tonnes (kt) of dust per year.
- Republic of Korea and Taiwan have a total of 5 plants with a combined capacity of around 600kt/year.
- China has only one plant dedicated to EAF dust processing.
- Europe has a total of 8 dust processors with a combined capacity exceeding 1 million tonnes (mt) of dust processing per year.
- North and South America have 8 dust plants. Combined capacity is above 1.2mt/year.
- **World:** 29 dust processing plants, capacity exceeds 3.2mt/year.
Zinc recovery from EAF Dust – Waelz Zinc Oxide

• All of the current EAF processors first convert dust to Waelz oxide (WZO). The WZO is sent mostly to zinc refiners for recovery of metallic zinc and the production of high grade zinc oxides. Current alternatives include making ferroconcrete or fertilizer and nutrients in the agricultural industry.

• An analysis of sampling of data on WZO produced from several dust processing facilities returned an average content of:
  – 61.4% zinc (min: 56 / max 66)
  – 7.2% lead
  – 4.2% Chlorine
  – 2.3% Iron
  – Traces of Cd, F, Na, K, Si and Ca

• Zinc recovery out of the dust should be on the order of 95% or more.
Zinc recovery from EAF Dust – Solvent Extraction

• The zinc recycling via the use of WOX in Electrowinning facilities has a limitation: WOX has to be mixed with Zn concentrates and its max proportion in this combination is 15%

• **Solvent Extraction** new technology can make it easier to produce Special High Grade zinc from WOX

• Already implemented by Horsehead (Mooresboro, US), Glencore (Portovesme, Italy) and Akita (Japan)

• By combining Waelz kiln technology, leaching, solvent extraction and electrowinning, it allows the production of high grade metallic zinc independently from energy intensive primary zinc smelters, and also the recovery of lead and silver

• However, it demands costly investment, does not permit iron recovery and it is difficult to meet Special High Grade standard
Zinc recovery from EAF Dust – Regulations

- There are increasing pressures to eliminate landfilling of EAF dust or its processing residues.
- Unfortunately, more and more these have become reasons to move steel making (and especially new mills) to countries with less restrictive regulations.
- There has been tightening limits on gaseous emissions generated by the major processing technology, Waelz kilns.
- There have been significant advances by the processors in these areas.
- The industry that generates the waste is itself also recycling another major waste (scrap steel), which allows much cheaper steel and higher productivity and lower energy consumption levels.
Zinc recovery from EAF Dust – Summary and Future Developments

- According to IZA and considering the end of life efficiencies, about 60% of the zinc contained in old scrap coming to end of life is ultimately recycled.

- Zinc can be recycled without damaging its metallurgical characteristics, and there are numerous advantages in recycling: reducing emissions, energy use and solid wastes, reducing risks associated with concentrate price’s fluctuations and supply disruptions and finally re-capturing the metal’s value.

- In recent years, one of the most dynamic areas has been the zinc recovery from electric arc furnace (EAF) dust.

- EAF dust results from steel recycling in Electric Arc Furnaces. This activity is now 30% of total steel production and increasing.
Zinc recovery from EAF Dust – Summary and Future Developments

• Zinc content in EAF dust varies widely, influenced by the composition of scrap used in EAF

  Average of 20% - 25% zinc content is commonly accepted

• Galvanized steel’s share in the scrap used in EAF is rising, which is increasing the zinc contained in the EAF dust, notably in China

• Of the 8.5 million tonnes of dust generated in 2014, 47% was recycled

  Production of 0.8 million tonnes of zinc!
  (6% of world’s total)

• Still around 4.5 million tonnes of dust to be processed + anticipated rise in new EAF production (within next 5 years)

  Potential for further expansion of dust processing
Zinc recovery from EAF Dust – Summary and Future Developments

- **Waelz kilns** are a proven technology and remain the predominant method of processing dust, with **over 85 % of the zinc processing market**
- World’s EAF dust processing capacity exceeds **3.2 million tonnes/ year**
- EAF processors first convert dust to **Waelz oxide (WZO)** containing an average of **around 60% zinc** sent mostly to zinc refiners for recovery of metallic zinc and the production of high grade zinc oxides
- **Solvent Extraction** combines Waelz kilns technology, leaching, solvent extraction and electrowinning, allowing **direct production of high grade metallic zinc independently from energy intensive primary zinc smelters**
- With only one EAF dust plant operating, **China** the most likely country to offer new opportunities for dust processing and Zn recycling
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