Recovery of metallic zinc as zinc oxide

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• ZINC OXIDE – A VERSATILE COMPOUND
• CHEMISTRY - VITAL FOR HUMAN, ANIMAL AND CROP NUTRITION
• PHYSICAL PROPERTIES – MOST EFFECTIVE RUBBER ACCELERATOR
• CERAMICS – ESSENTIAL ADDITIVE FOR MOST GLASS AND GLAZES
• ELECTRONICS - PREFERRED MATERIAL FOR VARISTOR MANUFACTURE
ZnO - Appearance
1. Zinc is the fourth most important metal in volume terms. World-wide production is around 14 million tonnes annually. Zinc oxide and chemicals account for about 13% of this level, on a metals basis. The major use for zinc is galvanizing. EAF dust from galvanized steel scrap processing is the major route for zinc recovery. Galvanizing process drosses are.

2. More than 85% of zinc oxide, ZnO, is made from metal, ie French Process. French process is combustion of zinc vapor in air. The balance is made by Direct Process from oxidic zinc, calcination (for Feed grade), as a co-product of sodium hydrosulfite and also Active ZnO via zinc carbonate intermediate.

3. French Process zinc oxide manufacture is very energy intensive. This is due to the zinc smelting operation to produce the metal and the furnace operation to vaporize zinc.
French Process ZnO
Regeneratively fired crucible furnace
French Process ZnO – Rotary Furnace
Larvik furnace
FRENCH PROCESS ZINC OXIDE

CHARACTERISTICS

• Microcrystalline white powder
• Size typically 0.25 microns, surface area 4 m2g-1
• Very pure product if made from SHG zinc, lead at around 15ppm is the only significant impurity.
• Secondary zinc oxide is typically 300 ppm lead.
• Oversize (+ 44 micron) typically below 0.02%
ZINC OXIDE GRADES

• ZnO manufacturers make several grades. The factors that determine the grades are-
  • Purity is determined by the zinc metal used and the furnace operation. High purity ZnO is produced from SHG (primary) zinc and lower purity (secondary) from galvanising.
  • Particle size characteristics, usually expressed as surface area.
  • Grit content, for rubber grade typically < 0.02% on a 44 micron sieve.
ZINC OXIDE PURITY

• Zinc boils at around 900°C and reacts with oxygen in the air. Impurity elements with lower boiling points (Cd) all report to the ZnO product. Higher boiling point elements (Pb, Al, Fe, Sn, Ni, Cr) tend to remain with liquid metal but can report to the product, depending on their concentration and boiling point. The major impurities in ZnO from secondary zinc are Pb and Cd.
ZINC OXIDE PARTICLES

• French Process ZnO is typically in the form of platelets of size below 1 micron. It can readily be examined with electron microscopy. For plant operation, BET surface area is used.

• The range of surface areas manufactured is typically 2.5 m2g-1 to 10 m2g-1. The standard product is 5 m2g-1, this is around 70% of the market. Some users have requirements which require specific surface area ranges.
ZINC OXIDE GRIT

• The manufacture process produces a proportion of grit as measured on a 325 mesh, 44 microns. This is separated from the ZnO fume using a grit catcher (or a cyclone). ZnO uses, such as rubber, require minimum grit which can cause tyre defects.

• Other less stringent uses, for example, ceramics and zinc chemicals can accept higher grit levels.
ZINC OXIDE GRADES

• In addition to the grades determined by purity, surface area and grit there are other grades-
• Pelletised ZnO for ease of handling. Hard pellets for ceramics, soft pellets for rubber.
• Coated zinc oxide to enable improved compatibility of the ZnO in the end-use product. Most common example is propionic acid coated ZnO for improved dispersion. The coating is carried out as the ZnO fume is being transported to the baghouse.
ZINC OXIDE CONSUMPTION BY INDUSTRY

Rubber
Ceramics
Chemical
Agricuture
Paint
Other
ZINC OXIDE CONSUMPTION BY AREA

Area

- N.America
- S. America
- Europe
- CIS
- ME, A
- Japan
- China
- SE Asia, I, O
### WORLDWIDE ZnO CONSUMPTION (1,000 TONNES)
**BY INDUSTRY AND AREA (2017)**

<table>
<thead>
<tr>
<th>Industry</th>
<th>N.A.</th>
<th>S.A.</th>
<th>E.U.</th>
<th>CIS</th>
<th>M.E. &amp;A.</th>
<th>China</th>
<th>Japan</th>
<th>S, E, Asia, I&amp;O</th>
<th>Total</th>
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<tbody>
<tr>
<td>Rubber</td>
<td>110</td>
<td>75</td>
<td>135</td>
<td>32</td>
<td>55</td>
<td>390</td>
<td>60</td>
<td>235</td>
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<tr>
<td>Ceramic</td>
<td>6</td>
<td>45</td>
<td>55</td>
<td>2</td>
<td>25</td>
<td>150</td>
<td>3</td>
<td>50</td>
<td>336</td>
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<tr>
<td>Chemical</td>
<td>40</td>
<td>5</td>
<td>45</td>
<td>4</td>
<td>14</td>
<td>50</td>
<td>8</td>
<td>20</td>
<td>186</td>
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<tr>
<td>Ag.</td>
<td>53</td>
<td>8</td>
<td>30</td>
<td>4</td>
<td>4</td>
<td>18</td>
<td>15</td>
<td>13</td>
<td>145</td>
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<tr>
<td>Paint</td>
<td>6</td>
<td>4</td>
<td>12</td>
<td>5</td>
<td>3</td>
<td>9</td>
<td>3</td>
<td>6</td>
<td>48</td>
</tr>
<tr>
<td>Others</td>
<td>25</td>
<td>3</td>
<td>33</td>
<td>5</td>
<td>3</td>
<td>85</td>
<td>10</td>
<td>10</td>
<td>174</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>240</td>
<td>140</td>
<td>310</td>
<td>52</td>
<td>104</td>
<td>702</td>
<td>99</td>
<td>334</td>
<td>1981</td>
</tr>
</tbody>
</table>
Zinc & Zinc oxide recycling

Galvanizing → in process, ash and dross
    → end of life, EAF dust
Brass → melting
Die cast → in process, dross recovery
    → end of life
Roofing → end of life
Chemicals → dispersive
Zinc Oxide uses - dispersive
Recycling zinc to metal or oxide

- Economic advantage - free air
- In process for example recovery of liquid zinc from ashes to hot dip galvanizing feed.
- Purification is possible by both melting and volatilization techniques.
Burns Energy Systems - Resource-efficient ZnO production

• Utilise available secondary materials -
  - Top dross, Bottom dross, Zn/Al drosses
• Minimise energy requirements
  - Regenerative burner technology
• Maximise product yield
  - Optimise process metallurgy and operation
• Meet or exceed product purity & quality requirements
Dross melter

This furnace is designed to dissolve dross in low iron zinc. Once in solution the dissolved iron is caused to react forming a ferrous precipitate. The precipitate is removed and the result is a low iron feed which may be used to make zinc oxide.
Melter
Melter
Liquid metal feed

This is part of an automation package that may be used with the twin retort furnace. Tundish shown is fitted with weigh cells.
Vaporising Furnace

This furnace is set-up for processing high lead content zinc secondary materials. The furnace is designed with a quick drain and fill feature that minimizes down time.
Regeneratively fired furnace

This furnace achieves production rates greater than most muffle type furnace technology and is less expensive to operate. It produces a high quality product and can be used for low lead content zinc secondary feed.
Design based on CFD

CFD modelling as used to help maximize crucible life and high quality ZnO productivity.
Zinc oxide recovery

• Zinc based battery technology is being adopted for energy storage. Batteries include-
  • Zn – Air
  • Zn – Ni
  • Zn – Fe
  • Zinc bromide flow batteries
Although each cycle could be viewed as ‘recycle’, recovery of end of life batteries will represent a new challenge
Thanks – Any questions?