IBA-gravel in road construction – upgraded to HP14 level

ISWA Working Group Meeting, 6. April 2017
Jens Kallesøe, Afatek A/S
Overview

IBA-gavel
1. About Afatek
2. New plant - recovery of metals
3. Recovery of minerals – increase value /HP14 challenge
4. Conclusion

Fly-ash cleaning residues
1. New organization in DK
2. Resource recovery – new technologies
Overview

1. About Afatek
2. The key to recover fine metals
3. Next generation metal sorting plant
4. Recovery of minerals – increase value
5. Conclusion – Where are we in the Circular Economy?
About Afatek

- Owned by 5 public waste companies - established in 1991
- 6 WtE plants incinerate 1,2 mill tons/y = 240,000 tons of Bottom Ash = 40 % of the DK market
- 3 sites for treatment of BA
- 18 employees (3 in research)
- 6-7 % ferrous, 1-2 % nonferrous, 90 % minerals for road construction. All Bottom Ash is recovered in Denmark.
The key to recover metals from the fines
Innovation process

- In 2008 we saw a large potential for resource recovery and cost reduction
- In 2011 one of the most modern, mobile plants was put in operation
- It was demonstrated 1) That we could recover metals of all types down to 2-3 mm (stainless steel down to 8 mm) 2) That it was profitable => reduced net costs
- 3 months of ageing resulted in dry ash – from the larger and most modern WtE plants

JENS KALLESØE, AFATEK A/S „RECOVERY OF RESOURCES IN BOTTOM ASH 2ND STAGE“ OCT 2016
Development of a semi dry process

Metal recovery from fine BA – Supported by the Danish EPA in 2014:

• Develop separation technology for fine metals
• Establish commercial metal potential
• Establish relation between metal yield and moisture content in fine bottom ash
Tests showed that dried up ash of about 10 - 15 % water can be screened down to 0,5 mm.
We could recover metals down to 0.5 mm
We found not only copper but also aluminium, silver and gold in the fines.

Rate and Composition of recovered metals

Melting results

NFE metals in band, [% of dry matter] 900 Hz

<table>
<thead>
<tr>
<th>Size (mm)</th>
<th>Light [%]</th>
<th>Heavy [%]</th>
<th>Gritsn. [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5-1 mm</td>
<td>0.32%</td>
<td>0.19%</td>
<td>0.52%</td>
</tr>
<tr>
<td>1-2 mm</td>
<td>0.31%</td>
<td>0.14%</td>
<td>0.52%</td>
</tr>
<tr>
<td>2-4 mm</td>
<td>0.38%</td>
<td>0.22%</td>
<td>0.52%</td>
</tr>
</tbody>
</table>

NFE metals in 0-50 mm [% of dry matter] 900 Hz

<table>
<thead>
<tr>
<th>Element</th>
<th>0-50 mm</th>
<th>0-50 mm</th>
<th>0-50 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blandet</td>
<td>Bl1 et Vest 14 2013</td>
<td>Bl1 et Vest 14 2013</td>
<td>Bl1 et Vest 14 2013</td>
</tr>
<tr>
<td>Cu</td>
<td>0.000001%</td>
<td>0.0000002%</td>
<td>0.0000004%</td>
</tr>
<tr>
<td>Ag</td>
<td>0.0000151%</td>
<td>0.0000001%</td>
<td>0.0000001%</td>
</tr>
<tr>
<td>Sn</td>
<td>0.00001%</td>
<td>0.00001%</td>
<td>0.00001%</td>
</tr>
<tr>
<td>Zn</td>
<td>0.00001%</td>
<td>0.00001%</td>
<td>0.00001%</td>
</tr>
<tr>
<td>Pb</td>
<td>0.0010%</td>
<td>0.0012%</td>
<td>0.0018%</td>
</tr>
<tr>
<td>Sn</td>
<td>0.0010%</td>
<td>0.0012%</td>
<td>0.0018%</td>
</tr>
<tr>
<td>Cu</td>
<td>0.000002%</td>
<td>0.00001%</td>
<td>0.00001%</td>
</tr>
<tr>
<td>Al</td>
<td>0.1207%</td>
<td>0.0759%</td>
<td>0.0831%</td>
</tr>
</tbody>
</table>

JENS KALLESØE, AFATEK A/S „RECOVERY OF RESOURCES IN BOTTOM ASH 2ND STAGE” OCT 2016
Next Generation Sorting Plant
New sorting plant ver. 2.0

3 lines for coarse bottom ash: 4 - 50 mm
3 lines for fine bottom ash: 0,5 - 4 mm
We can expect a recovery rate of more than 80%
Eddy-Current sorting technique + magnet taking fine iron

Fe: 1-4 mm (paper clips)
Eddy-Current sorting of Al and Cu-fraction (18-50 mm)
Eddy-Current sorting of Al and Cu-fraction (1-2 mm)
Sensor sorting of Stainless-fraction (18-50 mm)
Up-grading of the stainless steel fraction revealed large quantities of other metals – increasing total sorting efficiency

- Upgraded from 1 % to 15 %
  - (Sensor machine with air jets)
- Upgraded from 15 % to 95 %
  - (Crushing, screening, magnet, EC)
RECOVERY OF MINERALS
- Take it back into the loop at the highest value level
Increase product quality, market size and value - substituting highest quality gravel in road construction

All bottom ash is tested and declared in accordance to mechanical and physical properties:
- Water content
- Particle size distribution
- Density and water content needed for efficient compaction
- Classification test for the constituents of coarse recycled aggregate
- Total Organic Content (TOC)

Result:
- Since march 2012 all supplies of BA gravel from Afatek is declared
- Information about the construction product is now available for both the constructor and the controlling authority
- The bearing capacity test of the road in Copenhagen, may lead to use of BA gravel in higher road classes

Denmark has a long tradition for using BA in road construction – due to a clear government policy of using residues to substitute valuable virgin material
BA gravel in roads – unlimited?

Test road Nordhavn, Copenhagen
- Present: Limited traffic load
- Future: Unlimited traffic load
- Revision of standard for construction of roads, the Danish Road Directorate
Right pricing of IBA gravel?
Development of test method for HP14

<table>
<thead>
<tr>
<th>No.</th>
<th>Activity</th>
<th>Months</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Analysis of existing bottom ash data (composition, leaching data)</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>Stepwise classification, identification of pot. critical substances, worst case (1)</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>Identification of substances that may lead to classification as dangerous</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>Supplementary analysis in case No. 3 comes out positively</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>Establishment of test method and test criteria (2)</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>Check test method on selected samples</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>Evaluation of new legislation and developments in the Commission (3)</td>
<td>6</td>
</tr>
<tr>
<td>8</td>
<td>Arguments for having the model for testing acknowledged (DK &amp; EU)</td>
<td>5</td>
</tr>
<tr>
<td>9</td>
<td>Cooperation with others (ECN, VTT or other organizations)</td>
<td>4</td>
</tr>
<tr>
<td>10</td>
<td>Report with method, conclusions and recommendations</td>
<td>6</td>
</tr>
</tbody>
</table>

1) Council proposal from 8.3.2017  
2) ECHA’s “Guidance on the application of the CLP criteria” from 2012  
3) ATP9 – Commission Regulation (EU) 2016/1179 from 19.7.2016, as an amendment to the CLP

Revised hazard classification of MSWI bottom ash, ECN, Brussels October 24, 2016
- Ecotoxic effects are posed only when substances are in solution (ECHA guidance)
- Exposure from eco toxic substances is limited by their solubility and availability in the water phase

Danish Waste Solutions, Ole Hjelmar
Conclusion

• We can recover metals down to 0.5 mm – of all kinds, Fe, Al, Cu, Zn, Ag, Au and Stainless Steel

• Especially small pieces of metals built together with wooden, plastic or textile materials, can be recovered efficiently. Aluminium folio tend to melt into small lumps, making it easy to separate with ordinary Eddy-Current technique

• With a clean mineral part (slag gravel), we can substitute expensive, virgin building material (gravel from mines in DK)

• Expected further development: Optimisation of known technology and processes
Where are we in the circular economy?

- We don’t compete with recycling upstream – we complement.
- We can recover complex residues, plastic/paper/wooden stuff built together with iron/aluminium/copper/other metals – down to very small items, even folio.
- The mineral is taken back into the loop at the highest value level – by substituting gravel.
- Heat and electricity is also taken back into the loop – creating value from paper, plastic and others being too contaminated for recycling.
- Now we just need full EU acknowledgement - recovery of both the metals and minerals.
- All bottom ash (600,000 t/y) in DK is recovered. Nothing is landfilled.
Access to further information:

Learn more about Afatek and our projects at www.afatek.dk - here you will also find access to our results and reports.

Contact
Jens Kallesøe
Afatek A/S
Selinevej 18
2300 Copenhagen
+45 40290005
jka@afatek.dk