Goumans/Senden/van der Sloot, Editors
Waste Materials in Construction: Putting Theory into Practice

THE ABB DRY ASH CONCEPT: INREC™

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Abstract

ABB has developed and demonstrated a new way to sort and recycle ash from waste incineration. In this process, the bottom ash is kept dry and can therefore be directly separated into clean metals, construction material and a fraction suitable for smelting to yield a clinker substitute.

Where does bottom ash originate from?

In developed economies, individuals and businesses are encouraged to separate a number of waste materials for special treatment and recycling. At the same time, dumping of untreated waste is not longer seen as a sustainable solution and thermal treatment is favored. The waste which finally ends up in such a treatment plant is only the "remaining waste", a very special and rather unpredictable fuel, as the separation of waste fractions is subject to rapid change, both in space and in time. Fortunately, many efforts to collect waste separately affect several waste fractions at the same time. If, for example, green waste, paper and glass are separated, than water, fuel and inert material are removed and the overall composition of the remaining waste may not change too much.

Thermal waste treatment in a modern incineration plant with efficient flue gas cleaning combines several benefits: The organic fraction is destroyed and the energy content is recovered. A small amount of flue gas cleaning residues contains the toxic components like cadmium and mercury. About 10% of the waste volume, some 25% of weight remains as a mineralized bottom ash.

A cost-efficient process which produces marketable products from this bottom ash would provide the final missing link for a sustainable solution to the waste problem. ABB named this patented process InRec™ [Schwyter 1992], [Bürgin 1995].

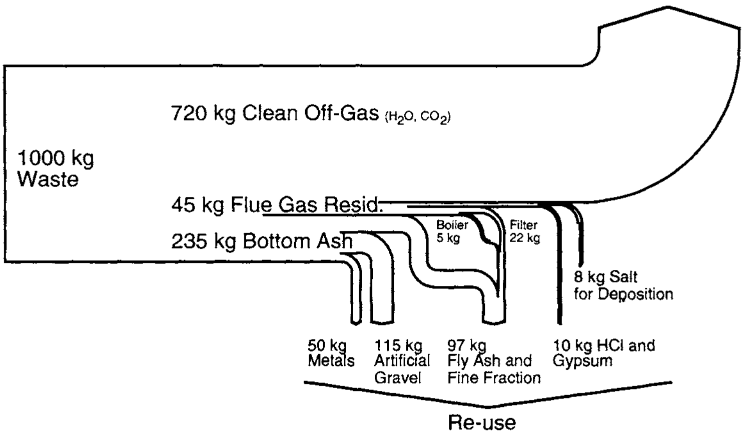

Fig. 1 Mass balance of municipal solid waste (example)

What is bottom ash?

Half of the ash consists of well-defined objects which did not change much during incineration: ceramics, bricks, glass, ferrous metals, brass, copper, sand, stones and so forth. The other half is real ash, mostly oxides and carbonates of the dominant elements of the earth' crust: Silicon, aluminum, iron, calcium and the alkali metals.

Potential problems arise from the heavy metal content of typically 1%, namely copper, lead and zinc. Additionally, chlorides may be a problem due to their solubility in water.

Chemically, bottom ash is very reactive due to the content of free calcium oxide (lime). With water, the strong base calcium hydroxide is formed, which results in a pH-value of more than 12 in the aqueous phase. Under these conditions, many elementary metals (e. g. iron and aluminum) are oxidized and can no longer be recycled:

$$2\ Al + 6\ H_2O \rightarrow 2\ Al(OH)_3 + 3\ H_2$$

Additionally, the hydrated lime causes hydraulic reactions with other oxides [Simon 1995], similar to those occurring during the formation of concrete, i. e.

$$Ca(OH)_2 + n\ SiO_2 \rightarrow CaO \bullet n\ SiO_2 + H_2O$$

This leads to mineral attachments on the scrap iron. Furthermore, it has been shown that the composition of bottom ash changes dramatically as a function of particle size (see Fig. 2). After hydratation, a separation of the more toxic fine material is impossible.

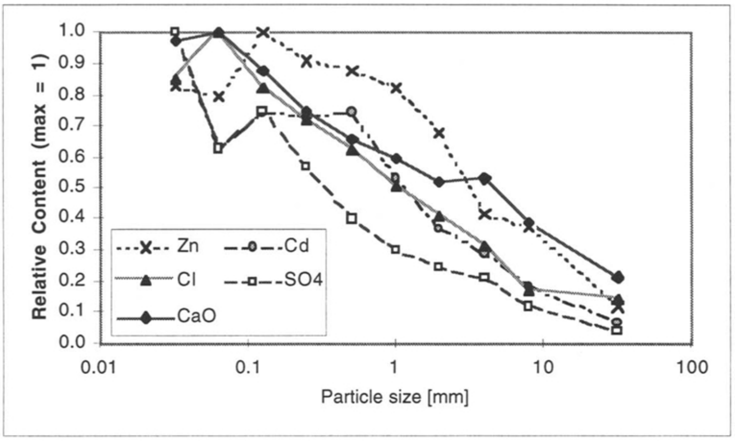

Fig. 2 Composition of bottom ash as a function of particle size (dry ash from a Swiss plant)

What is the InRec™-Process?

The InRec™ process is based on the idea to sort the dry bottom ash before any reaction with water takes place. Up to four modules may be combined to take full advantage of the process.

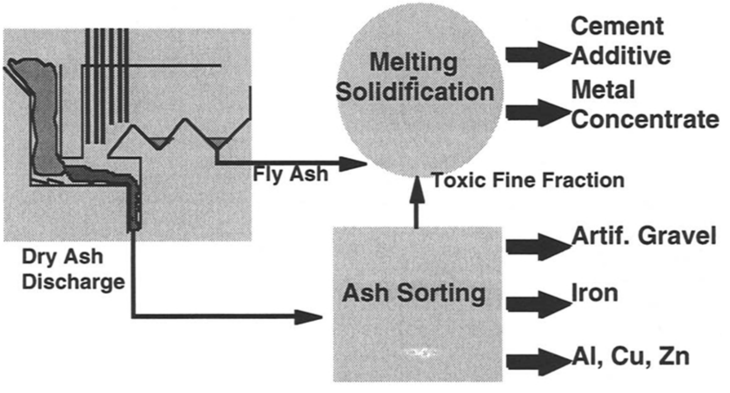

Fig. 3 The InRec™ Process - General Scheme

1. Ash formation

The W+E grate with Advanced Combustion Control provides the best possible ash quality: Repetitive roll-over of the waste fuel on the double-motion overthrust grate combined with a controlled supply of combustion air results in complete burnout of the waste and in a maximum transfer of the volatile components into the flue gas.

2. Dry discharge

The traditional water bath is replaced by a dry ash discharge system. Depending on the subsequent ash sorting, the ash can be discharged through a double-flap lock, which provides sealing to the atmosphere. In this case, the sorting process includes handling of the coarse fraction. Alternatively, a roller grate can be used to separate the coarse material within the ash discharge system. In this case, only the main fraction with particle sizes of up to 40 mm is discharged dry, while the coarse fraction is dumped into a water bath as usual. Both options have been installed in a Swiss incineration plant and were successfully tested for several month in 1995 and 1996.

3. Sorting

The sorting of the dry ash is performed with well proven mechanical components. In the first step, the fine fraction (i. e. particles smaller than 2mm) is separated with a Liwell-screen or by wind sifting. This way, the dust load for the following steps is minimized. Iron is removed by means of a magnet drum and an overhead magnet, while an eddy current separator is used to extract the non-ferrous metals from the bottom ash. To separate metals which are sintered to mineral material and to crush larger aggregates down to gravel size, a hammer mill is used.

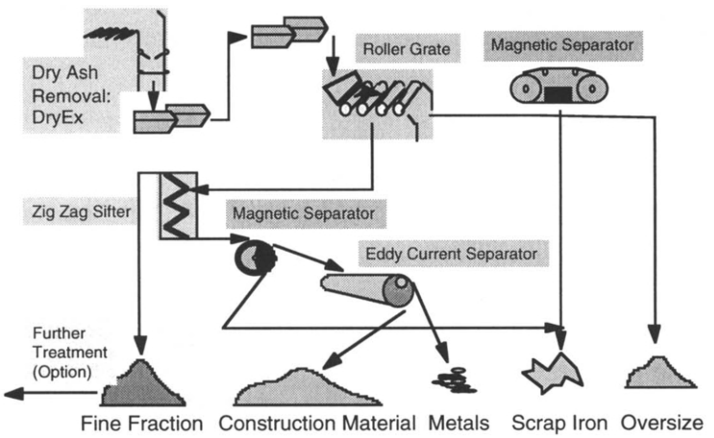

Fig. 4 The InRec™ Process: Dry Sorting of Bottom Ash

Details of the sorting process depend strongly on the desired use of the end products. However, usually 5 fractions are obtained:

- 50-60% main mineral fraction (particle size i. e. 2-40 mm) for construction purposes
- 15-20% ferrous metals
- 1-2% non-ferrous metals, of which typically 2/3 is aluminum and 1/3 is copper and brass
- some coarse fraction (amount and composition depends individually on the incinerator)
- 15-30% fine fraction for further treatment

All the mechanical components of the sorting process have been tested in full size with InRec™ material.

The metals are recovered in an unsurpassed high quality, so that they achieve good revenues on the recycling market. The mineral fraction passes the common leaching tests, so that the use in road construction is possible in most countries. Test of an independent lab have proven, that also the mechanical properties are satisfactory for such reuse.

4. Smelting of the fine fraction with AshArc™

As most of the toxic components of bottom ash are concentrated in the fine fraction, further treatment is required. If reuse of this fraction is desired, is can be treated in the AshArc™ process.

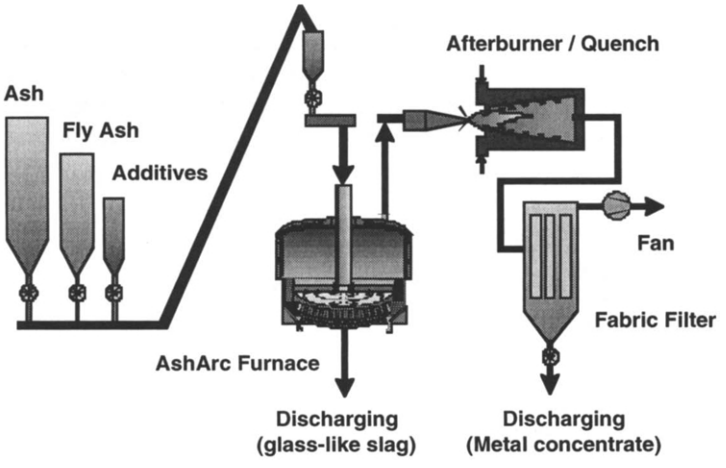

Fig. 5 The AshArc™ Process

AshArc™ is a modification of the ABB DC arc furnace which is currently operated in more than 30 installations in the metallurgical industry. The ash is fed into the furnace through a hollow electrode. It is melted by an electrical arc which burns between the graphite electrode and the molten metal anode on the bottom of the furnace. Depending on the furnace throughput, the molten ash is discharged batch-wise or continuously. Most of the salt content, zinc and lead is evaporated. The graphite electrode provides a reducing atmosphere in the oven, which further helps to reduce the metal content of the ash as elemental metals are collected separately on the bottom. To prevent formation of toxic organic compounds, the exhaust gas is first passed through a CO afterburner and then cooled rapidly with air. The evaporated chlorides and metals resublime and are removed by bag filters. The filter cake, a heavy metal concentrate, can be recycled in the metallurgical industry. The flue gas is further cleaned with standard methods to remove SO2 and HCl.

Additional benefit can be achieved by treating the waste incineration fly ash together with the fine fraction.

The AshArc™ process has been tested in full scale to determine its suitability for melting bottom ash. 50 tons of bottom ash and fly ash were melted to products which even met the tough requirements of the cement industry. Leaching requirements for use in various construction applications are easily met (DEV-S4, Swiss TVA for „Inertstoffqualität" etc.).

If vitrification is not desired, to save costs and energy, the fine fraction with its high lime content can simply be stabilized or solidified by mixing with water and clay or cement. The suitability of this fraction for flue gas cleaning purposes is currently being tested.

Conclusions

InRec™ enables the total recycling of waste incineration bottom ash, without the effort of melting the whole material. Therefore, it provides the potential to recover the energy and the metal content of the mixed household waste, plus producing artificial gravel for construction. Continued efforts to reduce the heavy metal input into the waste will additionally increase the reuse potential of the ash. The treatment cost of such a process is comparatively low, especially if the AshArc™ melting process is omitted. Compared to a modern treatment process for regular (wet) ash, considerable savings can be expected. This is due to the simplified ash discharge, easy storage and better efficiency of the sorting plant combined with an increased market value of the resulting products.

Bürgin, M., Schmidt, V. and Simon, F. (1995), Verfahren zur Rückgewinnung von Wertstoffen aus Müllverbrennungsschlacke, European Patent Office, EP 0 0691 160 A1

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