Direct Wet Treatment of Fresh, Wet-Discharged Grate Ash from a Waste Incineration Plant

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Since 2013, Brantner runs a plant for wet reprocessing of incinerator bottom ashes (IBA) from municipal waste incinerators (MWI) with the Brantner wet slag (BWS) process. Through continuous enhancements, the process was extended with a fine slag treatment plant in 2017. In addition to the conventional processing, such as magnetic separation and eddy current separation, the density separation with a jigger and gravity concentrator was installed as a third process technology. Because of this combined process, metal recycling from IBA starts from a grain size of 0.05 mm. In addition to the recovery of metals in smelter quality, the production of construction material is another aim of the process.

1. Incinerator bottom ashes from municipal waste incinerators

IBA are hard residues from municipal waste incinerators. Most IBA are discharged through the combustion grate from the firebox to a wet deasher. The wet deasher serves as an air seal to the combustion chamber, c ools the slag and extinguishes burning waste. Some MWI are working with a dry discharge and the IBA have to be handled in a completely enclosed treatment plant due to high levels of dust. There is no own experience with dry-discharged IBA in wet processing, therefore only wet-discharged IBA as discussed in this article.

Due to the inhomogeneous composition of the incinerated waste, IBA are very diverse and contain a variety of valuable resources and harmful substances. The grain sizes vary from dusty ashes of a few micrometers to massive concrete and steel parts of several hundred kilograms. The portion of fine particles depends on the composition of the waste. Incinerated sewage sludge or wood ashes and can greatly increase the fines. The medium grain size is about 6 mm. The fine fraction below 3-4 mm (about 30-40 %) cannot be de-metalized through conventional drying processes.

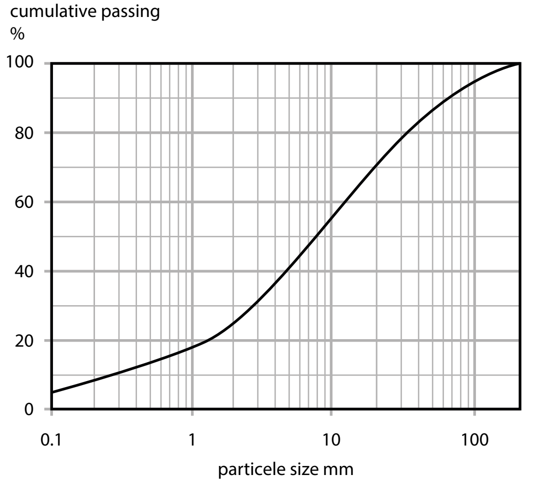

Figure 1:

Typical grain size allocation from primary municipal waste incinerator slag

Source: Bunge, R.: Recovery of metals from waste incinerator bottom ash. Rapperswil: UMTEC, 2015

The vast majority of IBA consist of a mineral fraction that contains so-called runners and combustion residues (ashes). Mineral waste such as glass, ceramics, artificial and natural stones, concrete and brick are typically runners. These undergo the incineration process without significant changes and are still clearly recognizable after the incineration process. The incinerator ashes manly consist of mineralized residues.

If the ash is heated above the softening point and solidifies, it will form mineral phases (slags). Regeneration and transformation of the mineral phases start immediately after leaving the incinerator. This transformation also continues before and after de-metallization and conditioning of the IBA. [2]

The percentage of runners and ashes depends on the composition of the input waste and the configuration of the incineration technology.

IBA also contains metals, such as ferrous (FE) and non-ferrous (NF) and small amounts of unburned waste. Metals may be present as unaltered runners (e.g. stainless steel) or as fused parts or nuggets (aluminum, copper, brass, ...). The metal content is based on the gross domestic product (GDP) of the waste generators [1].

Some metals dissolve relatively well in the silicate melts or appear as oxides, sulfates or other compounds [4]. The recycling of these metals is very limited in any process. But a treatment such as ore mining with grinding, flotation or leaching is conceivable for these metals.

IBA contain CaO and other cohesive substances. Contact with water in the wet deasher and CO2 (from air), starts the carbonation and the fresh IBA harden after a few days or weeks into a solid monolith. The metals are firmly embedded within this monolith.

IBA are removed from the ash with heavy machinery and broken into smaller parts. The metals which are sorted out of the IBA with this technology are contaminated by ash caking. The caking constricts a decent sortation and reduce the value of the metal concentrate.

Small aluminium parts can be oxidized while aging already within a few hours or days and are no longer available for recycling [3].

2. Wet processing of incinerator bottom ashes

The valuable ingredients enable us waste to be recycled. Due to the increasing complexity of many products, material-recycling of some valuable materials is not economically or technically viable. One way to recycle complex waste is the thermal treatment of waste and the subsequent processing of the incineration residues.

IBA are the residues of waste incineration and can be compared by their properties and potential applications with mineral products such as gravel, rocks or ores. Complex and high-quality treatment processes in gravel and ore conditioning use wet processing. As difference to dry treatment processes, a liquid working medium is used in wet processes. This working medium is usually water. The use of water as a working medium in the processing of IBA requires new process concepts in order to be able to optimally use advantages and minimize the disadvantages.

One of the biggest advantages of wet processing is the immediate processing of the IBA after combustion and the resulting higher metal yield. The usual storage time for aging the IBA of several weeks or months can be eliminated and makes the process cheaper. The direct wet treatment after waste incineration is possible by washing off cohesive fine grain from the IBA. The carbonation and setting processes take place predominantly in the fine grains with a size smaller than 0.1 mm. While the coarse grain above 0.1 mm remains pourable and does not polluted the downstream processing machines.

Fine grain smaller than 0.1 mm has about 5-10 % dry matter at the IBA and requires special treatment. By co-incineration of sewage sludge or other fine-grained waste, the fine grain content may be considerably higher. Harmful substances such as antimony, lead, chromium, corrosive salts, CaO and adhesive grain are enriched in fine grain. If the fine grain gets washed and separated from the IBA, hazardous substances smaller than 0.1 mm can be removed from the IBA. This process improves the usage of the coarse grain as construction material.

A main issue with wet processes of IBA is the supply of sufficient process-water and the subsequent disposal or purification of contaminated process-water. This problem can be solved by recycling the process-water through an integrated water treatment in a closed loop system.

The fines in the IBA may have different properties depending on the composition of IBA and the treatment of the process-water is rather difficult.

The purification of the process-water is a key technology of the wet processing of IBA. Very stable foams can arise on the process-water. These foams persist for several days and dissolve slowly. A mechanical destruction may be required. The intensity of the foaming occurs with varying intensity and can reach a height up to one meter. Appropriate chemical dosing in the onset of the foaming prevent the formation of foams.

Depending on the incinerated waste, the dosed chemicals are varying too. The quantities and costs vary greatly depending on the used wet process. To remove fine grain from the ashes, a friction-wash is required. This friction-wash can be done for example by a sword washer or by a jigger.

The jigger combines several process steps in one machinery. During the stay of the IBA in the jigger, the ash grains move up and down and rub against each other during each lifting movement. The fine grain can be removed with the screen in the jigger and fed to a fine slag treatment plant with a connected water treatment. The core function of a jigger is the separation of materials with different densities. Four fractions can be generated with a special jigger. Figure 5 shows an overview of the fractions. The main fraction is a mineral light fraction consisting of ashes, stones, glasses, ceramics, bricks and other mineral components which are discharged by an overflow weir from the jigger. This fraction also contains the aluminium. The light fraction gets dewatered and the aluminium is separated with an eddy current. Due to the absent adhesive grain, aluminium can be recycled very well and in high purity from the ashes. The use of the aluminium concentrate in aluminium smelter is possible. A residual metallic aluminium content of less than 0.1-0.5 % (measured grain larger 1.0 mm) for the entire grain spectrum is possible with one eddy current separator. The strong fluctuations in the residual aluminium content comes from different used analytical methods.

Figure 2:

Aluminium concentrate, smelter grade

In the jigger, a heavy metal fraction gets out of the jigger at grounds with a flap. In this heavy metal fraction are the metals with a density greater than 4 g/cm³ such as copper, brass, stainless steel and other heavy metals. Heavy metals, which normally cannot be separated with an eddy current separator, are reliably recycled by the density separation. These metals include stainless steel, lead and precious metals. Because of the density separation, about 20 % more heavy metals can be recycled. The extracted heavy metals are washed clean by the jigger and can be sold directly to copper smelter companies.

Figure 3: Heavy metal concentrate fine, smelter grade

Figure 4: Heavy metal concentrate, coarse

As fourth fraction the jigger can separate a floating fraction, which consist of plastics, wood and lightweight concrete.

The separation of the floating fraction is important for the production of construction materials from IBA. The salt and residual metal content should be low in addition to a small proportion of the floating fraction in construction materials made from IBA.

The salt load accumulates in the fine grain smaller than 0.1 mm and can therefore be withdrawn from the construction material fraction that is bigger than 0.1 mm.

Fine grain smaller than 4 mm normally cannot de-metallization by conventional dry treatment plants. This treatment takes place in a fine slag treatment plant with gravity concentrators. As a result, heavy metals with a size of approximately 0.05 mm can be recycled from the IBA. Fine aluminium parts are sorted with an eddy current. In the fine metal, copper, zinc, lead, antimony and other heavy metals accumulate and discharge the building material fraction.

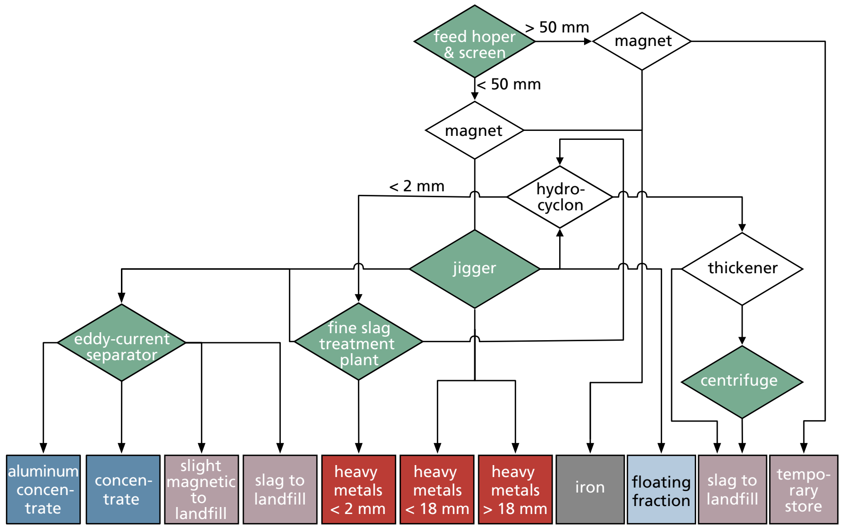

Figure 5: Processing scheme wet processing IBA

3. Summary

Direct wet treatment of fresh, wet removed IBA from waste incineration enables ash-processing without previous *ageing*, resulting in a significant increase in the amount of recovered metals with grain size bigger than 0.05 mm. This increased metal recovery rate is caused by the metal components not embedding into the matrix of the ash due to the lack of *ageing*.

The metals recovered through this process are of considerable high quality – containing various metal concentrates – and are therefore suitable for direct delivery to smelting works or floating plants. Additionally, the separation of fine grain metals increases the quality of the residual slag, rendering it viable for usage as concrete aggregate, in the cement production industry, or as bounded or unbounded layers for road construction.

The predominant technologies used in this wet process are magnetic separation, eddy current separation, density separation, and gravity separation with the main benefit being, that the process does not generate any dust emissions.

In conclusion, the wet slag treatment of IBA is a simple and cost-effective process for recovering valuable raw materials, and therefore another step towards a circular economy.

4. References

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