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Journal of Hazardous Materials B128 (2006) 27–38

Journal of Hazardous Materials

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Effect of improving flue gas cleaning on characteristics and immobilisation of APC residues from MSW incineration

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Abstract

The flue gas cleaning system of a MSW incinerator with a capacity of 350 kt/year was changed to improve the HCl elimination efficiency. Instead of the semi-wet operating spray reactor and subsequent baghouse, a two-step wet flue gas cleaning was added behind the baghouse.

Elemental composition, X-ray powder diffraction patterns and TGA measurements showed that the resulting APC residue was totally different from the former residue. As a consequence, leaching characteristics of both residues also differed and another treatment was required prior to disposal.

For the former residue, mainly leaching of Pb (>100 mg/l), necessitated treatment prior to landfilling. The lower alkalinity of the new residue resulted in a leachate pH of 9.7 and a Pb concentration of 0.8 mg/l. The leachate pH of the former residue was 12.4. The leaching of Pb and Zn increased above 100 mg/l when immobilising the new residue with cement. Better results were obtained when immobilising with micro silica.

The high $CaCl_2 \cdot 2H_2O$ content of the new residue brought along clogging of the bag filter system. Adding 1.4% of CaO (or 1.9% of $Ca(OH)_2$) to the residue already improved these inconveniences but again significantly changed the leaching behaviour of the residue.

Keywords: Flue gas cleaning; HCL emission; APC residue; Metal leaching; Waste to energy

1. Introduction

Air pollution control (APC) residues of municipal solid waste (MSW) incinerators are hazardous wastes due to the high content of heavy metals and organic pollutants so that they must be landfilled at specialised disposal sites. Safe disposal implies a treatment to prevent leaching of contaminants and soluble salts, to prevent dust formation and to preserve the stability and accessibility of the landfill. Immobilisation is the most commonly applied technique for treatment of APC residues. Other techniques are acid extraction and melting (Ecke et al. [1]). Main residue characteristics, such as alkalinity, soluble salt content, contents of major elements and mineralogical composition, determine the leaching behaviour of the hazardous compounds present in minor concentrations. Changes in residue characteristics and thus in leaching behaviour can require changes in the immobilisation recipe.

The aim of immobilising residues from waste incineration is to reduce leaching of heavy metals of which Pb and Zn are of most concern. The solubility of both metals is highly pH-dependent and is minimal at neutral pH. Various additives are promoted to be effective in reducing the solubility of these metals. Among these, often miscellaneous additives, cement is the cheapest additive that can reduce leaching of Pb and Zn in neutral to alkaline conditions. The immobilisation mechanism is supposed to be related to the incorporation of the metal in the calcium–silicate–hydrate structure, which is the main constituent of hydrated cement. Soluble phosphates are used because of the formation of low soluble pyromorphite. In a previous study, it was indicated that adding various silica-containing additives to APC residues can result in decreased leaching of Pb and Zn.

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doi:10.1016/j.jhazmat.2005.07.004

In this paper, we discuss the effect of changes to a flue gas cleaning (FGC) system to improve acid gas removal efficiency, on the chemical and mineralogical composition of the main phases of the APC residue. Also, the effect of these changes on leaching of the untreated and treated residues is compared and discussed. The studied residues were treated with cement, micro silica and Na_2HPO_4 as soluble phosphate. The efficiency in reducing leaching of Pb, Zn, Cu and Cd by the different treatments for the different residues is compared.

The studied residues originate from the largest municipal waste incinerator of Flanders. In 2001, the capacity was increased from 200,000 t/year (two lines; 26 t/h in total) to more than 350,000 t/year (three lines; 48.5 t/h in total). This increase in capacity was attained by adding a third incinerator line consisting of a waste bunker, a grate furnace, a steam boiler and an electricity generator. The increase in total capacity made a decrease in emissions for the three lines necessary. Below 30 t/h total capacity, the emission limit values are 30 mg/Nm^3 dust, 20 mg/Nm^3 TOC, 50 mg/Nm^3 HCl and 300 mg/Nm^3 SO_2; above 30 t/h limit values are: 10 mg/Nm^3 dust, 10 mg/Nm^3 TOC, 10 mg/Nm^3 HCl and 50 mg/Nm^3 SO_2 (AMINAL [2]). Experience and studies have shown that the HCl removal efficiency of Ca-based sorbents increases with increasing humidity (Liu et al. [3]). Therefore, to guarantee these lower emissions, a wet FGC system was added and purged wash water was recycled in a spray dryer placed before the baghouse. The composition of the APC residue of the new plant differed significantly from the original plant as a result of this change. In addition, it was observed that with the new FGC system clogging or fouling of bag filters occurred at certain moments and that residue stuck to inlet valves of the baghouse. Adding 1.4% CaO (or 1.9% $Ca(OH)_2$) to the residue by injecting lime milk in the spray dryer or dry powder in the duct between spray dryer and baghouse could solve these problems to a large extent. Ideal results were obtained by adding 20% of $Ca(OH)_2$ to the residue. This optimisation is not part of this study. This supplementary $Ca(OH)_2$ again changed residue characteristics. These changes and the effect on leaching and immobilisation were also studied.

The paper describes chemical characteristics, leaching and treatment of the former residue, the residue after installing the wet flue gas cleaning system (new residue) and the residue after supplementary CaO addition. The paper wants to illustrate that small changes in flue gas cleaning system can result in significant changes in residue characteristics. A correct cost estimate for the treatment of the residue from flue gas cleaning is most often not done. The knowledge described in this paper can be useful for a correct cost estimation of changes in flue gas cleaning system.

2. Materials and methods

2.1. Plant description

The former plant consisted of two identical lines each having a capacity of 13 t/h. Each line had a FGC system as shown in Fig. 1 consisting of a semi-wet spray reactor placed behind the steam boiler and before a baghouse. Activated carbon was injected in the cone of the spray reactor. Eighteen kilogram of lime per ton of waste was injected in the spray reactor as slurry to neutralise acid gasses, such as HCl and SO_2. A sample of the APC residue was taken from the baghouse and stored in airtight 10-l containers. The residue is called “former residue” throughout the text.

The new plant consisted of three lines (two of 13 t/h and one of 22.5 t/h). The adapted FGC system is shown in Fig. 2 and consists of a spray dryer placed behind the steam boiler and before a baghouse. Behind the baghouse, a wet FGC system is placed consisting of two stages. In the first stage, a slurry containing 25% $CaCO_3$ is used to remove HCl. In the second stage, a 10% $Ca(OH)_2$ slurry is used to neutralise SO_2 and residual HCl. Spent water from the wet FGC is passed through a hydro-cyclone to remove wet gypsum (300 g/l). Wet gypsum is passed over a belt sieve. Water from

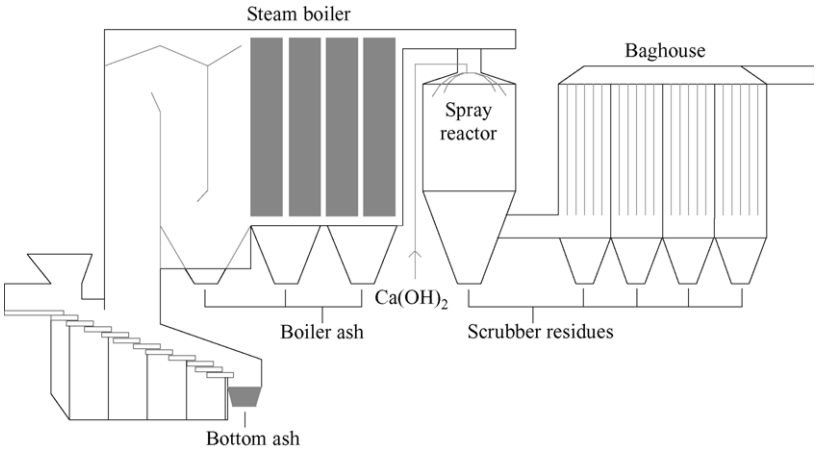

Fig. 1. Former flue gas cleaning system of the plant (two lines) with a total capacity of 26 t/h.