Waste to Wealth: Incinerated Municipal Solid Waste Ash

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ABSTRACT

In developing countries such as Malaysia, waste management is becoming an acute problem as urbanisation and economic development increased rapidly. Due to deficient of landfill spaces, incineration is gaining increasing consideration from the government as an alternative method of solid waste management. Although 95% reduction in solid waste volume can be achieved by incineration, it produces large amount of ashes. Using the concept of powder metallurgy, the ash is treated as powder and its commercial potential is discussed.

Keywords: *Bottom ash, fly ash, powder metallurgy, sintering process*

Introduction

Overall, with a population of 24 million, Malaysians generate 16,000 tonnes of municipal waste per day and the amount per capita varies from 0.45 to 1.44 kg per day depending on the economic status of the areas concerned. In general, waste generation is about 1 kg per capita per day (GAIA Global Meeting, 2003).

Approximately 95-97% disposal of municipal waste in Malaysia is done through landfill (Consumer's Association of Penang, 2001), while the remaining waste is diverted to recyclers/re-processors or is dumped illegally. There are 168 disposal sites throughout the country, of which only 7 are sanitary landfills. The rest are open dumps and about 80% of these dumps have been filled up to the brim and have to be closed in 2005. The federal government had spent RM 20.9 million to build another 9 sanitary landfills and upgrade 27 existing landfills in 34 designated areas (GAIA Global Meeting, 2003). These measures are, however, insufficient to overcome the problem of waste disposal as the waste generation rate is increasing rapidly due to high population growth and urbanisation.

Hence, the federal and state governments are now considering to build incinerator plants in major cities and towns. Incineration has the potential to solve the problem of landfilling as the original volume and weight of wastes may be reduced up to 95% and 75% respectively (Japan Society for the Promotion of Science, 2007). This will help to prolong the

lifespan of landfill sites up to 10-20 times (Japan Society for the Promotion of Science, 2007). Even though incineration seems to be the answer to the problem of limited landfill spaces, it produces large amount of incinerated ash. There will be 800 tonnes of ash generated everyday which will amount to about 24,000 tonnes a month. This problem can be solved by knowing the advantages, usage and the potential importance of ashes.

What is Incineration?

Incineration is a treatment technology involving destruction of waste by controlled burning at high temperatures (Roberts et al., 1999). It reduces the quantity of waste products prior to their final disposal. While incinerators can operate without being used for energy production, the steam heat generated by incinerators can produce as much as 100 megawatts of electricity. Many municipalities utilise this as an electrical source. This allows for the recovery of energy for electrical and heating purposes, and reducing the use of fossil fuel energy sources.

It produces two types of residue; fly ash and bottom ash. Fly ash is the material that becomes airborne in the incinerator and is collected in either the incinerator stacks or in the air pollution control equipment. Bottom ash refers to the residue, which remains on the incinerator stoker and grating system during the combustion process (Mohd Rashidi & Ismail, 2006). Fly ash is hazardous and comprises 1-3% of the original waste volume. These materials require special handling for disposal. In the other hand, according to the European Waste Catalogue, incinerated bottom ash (IBA) is classified as non-hazardous waste (Fillaponi et al., 2003).

Fly Ash

Physically, fly ash is a very fine, powdery material, composed mostly of silica, and nearly all particles are spherical in shape. Generally, the range sizes of this particle are from 0.5 μm to 100 μm. The color of fly ash can be varied from grey to black depending on the amount of unburned carbon in the ash. The lighter colour shows that the carbon content is lower. This gives fly ash a consistency somewhat like talcum powder. Because of its spherical shape, fly ash is very useful in cement and concrete applications.

Based on Table 1, the principal constituents present in the ash are lime (CaO) and silica (SiO_2). The composition of fly ash is influenced by

the type of fly ash, incinerator and input waste (Feng-Yim Chang & Ming -Yen Wey, 2006).

Table 1: Chemical Composition of Fly Ash (Feng-Yim Chang & Ming-Yen Wey, 2006).

	Fluidized Bed	Mass Burning	Rotary Kiln
CaO	12.44	22.24	17.40
SiO_2	22.08	0.13	6.74
Al_2O_3	1.55	1.19	0.15
Fe_2O_3	6.77	0.81	0.51
MgO	1.28	0.78	0.82
Na_2O	7.16	8.75	8.21

Bottom Ash

Incinerated Bottom Ash (IBA) generally consists of coarse particle of slag, glass, rocks, metal and unburnt organic matter (Chimenous et al., 1999). Bottom ash has angular particle with very porous surface texture. Bottom ash particles range in size from fine gravel to fine sand with very low percentage of silt-clay sized particles which about 0.1-100 mm (Moulton, 1973). IBA has a great potential to be used as a replacement for sand due to its similarity to sand in grain size distribution (Chimenous et al., 1999). It has been used as a substitute for valuable primary aggregate in the construction of roads and embankments. Major elements in bottom ash which accounted 50% of its weight were Si, Ca, Al, Fe, Na, Mg, K and C. Table 2 presents the chemical composition of bottom ash.

Table 2: Chemical Composition of Bottom Ash (Moulton, 1973)

Chemical Composition	% of Weight
CaO	0.4
SiO_2	53.6
Al_2O_3	28.3
Fe_2O_3	5.8
MgO	4.2
K_2O	0.3
Na_2O	1.0

By studying the chemical composition of incinerated municipal solid waste ash, the composition of ash which is mainly of SiO might have a degree of compactibility and can be sintered like those of many metal and ceramic materials. Using the concept of powder metallurgy approach, the ash is treated as metallic and ceramic powders used in conventional process to be recycled to form value added materials.

Introduction to Powder Metallurgy

Powder metallurgy is a forming and fabrication technique consisting of three major processing stages. First, the powdered materials are blended and sometimes require mixing. Next, the powder is poured into desired shape of mold and compacted. This is the most common means for shaping and densifying the powder. The compacted powder is then sintered at high temperature with long setting time. The sintered product produces a mechanically strong material as the particles bond together (German, 2005).

Sintering Process

Sintering is a method to form objects from powder by heating the material below its melting point until its particles adhere to each other. During sintering, pores between the starting particles are removed together with the growth together and strong bonding between adjacent particles (Mohd Rashidi & Ismail, 2006). After the sintering process, particle of the ash bind to one another and form greater strength. Normally, particles will bind together when heated to relatively high temperature. Shrinkage also occurrs in sintering process where the component will shrink to a smaller dimension.

Potentials of Incinerated Municipal Solid Waste Ash (MSWA)

The zero-cost raw material of incinerated municipal solid waste ash (MSWA) has the advantage of low density, lightweight and high in strength especially after being sintered. Having that benefits, powder metallurgy method possible the ashes to be recycled to form value added materials as listed in Table 3. Other possible applications of ashes are cement replacement, soil stabiliser, paint, binder, plaster and sludge conditioner.

Table 3: Potentials of Incinerated MSWA from Powder Metallurgy Method

Application	Possible Usage
Lightweight concrete	Coastal protection, house construction and insulation
Roofing sheet	Building insulation
Aggregates	Road pavement, embankments, decorative materials
Ceramic products	Decorative materials
Particle board and panels	Decorative materials, insulation
Tiles	Decorative materials, wall finishes
Bricks and blocks	Coastal protection, house construction and insulation, pavement, road construction

Conclusion

Incinerator does not solve the waste problem. It just transforms the garbage to large amount of ashes. Therefore, the development of reused product in protection of the environment should be encouraged and produced. Reutilising this waste material via the concept of powder metallurgy will help to eliminate the ash, reduce the disposal area, conservation of natural resources such as natural aggregate, mitigate potential environmental impacts and generate the new economic value.

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