Effective Utilization of Fly-Ash from Power Plant for Cement Production

YOSHIYUKI UENOYAMA
General Manager
Green-Innovation Business Promotion Department
TAIHEIYO CEMENT CORPORATION
yosiyuki_uenoyama@taiheiyo-cement.co.jp
Taiheiyo Cement’s activities span the world

Locations of Taiheiyo Group’s cement plants

Oversea Sales: 22,649kt (2009)
- U.S.A. 2,035 kt (9.0%)
- China 4,766 kt (21.0%)
- Korea 12,815 kt (56.6%)
- Others 3,033 kt (13.4%)

Domestic Sales:
- 14,829 kt + Export 5,009 kt
Contents

- Outline of dry process of cement production and energy efficiency
- Recycling - utilization of by-products and industrial waste including coal fly ash
- Taiheiyo's advanced technology for utilizing MSW incineration ash
- Conclusion
Typical cement production process

1. Mining

- Belt conveyor
- Limestone
- Iron slag
- Clay minerals

2. Raw material process

- Raw mill
- Homogenizing silo
- Clinker silo

3. Burning process

- Coal
- Coal mill
- Rotary kiln
- Clinker cooler

4. Shipping

- Cement vessels
- Freighters
- Bulk trailers
- Bags

4. Finishing

- Finish mill

Material flow
Fuel flow
Gas flow
Raw material for cement

Cement is made from Limestone, Silica, Clay and Iron slag

- **Limestone:**
  Occupying 70-80% of total raw materials and transported from a mine by a belt conveyer, for instance

- **Iron slag:**
  By-product of iron manufacturing

The composition of raw material effects property of cement
Burning process

Excellent cement can be manufactured by burning at very high temperature of 1450 °C

1. Raw material is heated gradually by hot gas in the preheater
2. Preheated raw material is burned in the rotary kiln at a temperature of 1450 °C
3. Approximately 30 min of burning, the raw material turns red-hot lava like lumps

Preheater (back) of 65m in height and Rotary kiln (fore) of 5.4m in diameter, 95m in length, 3200 ton/day production capacity, 250 kW powered

Inside view of Rotary kiln operating at a very high temperature of 1450 °C
Finishing process

Grinding clinker with gypsum into fine powder, that is cement

Clinker

Gypsum

Finish mill
Power required: 3875 kW
Milling capacity: 120 ton/h
Size: 4.6m dia. and 13.1m

Classifier

Cement

To control setting time of cement
Difference of wet-process kiln in energy efficiency

Providing slurred raw material directly into rotary kiln

Schematic wet-process cement kiln

Specific required heat and production on various types of kiln
Specific required energy and energy efficiency

Typical technology on heat efficiency
- NSP type burning system
- Five-cyclone cascaded preheater
- Air beam type clinker cooler
- Pulverizing coal constant feeder
- Automated quality monitoring

Typical technology on power efficiency
- Vertical type mill
- Pre-grinding system
- High efficiency classifier
- High efficiency blower fan

Transition of unit heat energy

Transition of unit power

2013 © TAIHEIYO CEMENT
The top runner on energy efficiency

Comparison of Energy consumption index on clinker and cement manufacturing

Business scheme of material recycling

Practically performed “Waste to Resources” business scheme on cement plants

Conservation of natural resources
Prevention of global warming
Elongation of landfill service life

Natural resources

Industrial clustering
- Steel plants
- Coal fired power plants
- Others waste tires waste plastics

Blast furnace slag
Coal fly ash
Desulfurazation gypsum
Limestone & slaked lime
Alternative fuel & raw materials

Cement plants

Recycling of municipal waste
- Incineration ash
- Separation and Incineration
- Raw materials
- Mixing admixtures
- Incineration ash
- Incineration

Sewage sludge
General household

Cement and concrete products

2013 © TAIHEIYO CEMENT
Utilizing by-products and waste

Why by-products and waste can be utilized at cement plants?

Because:

1. Cement majorly contains CaO, SiO$_2$, Al$_2$O$_3$ and Fe$_2$O$_3$. Waste containing such components may be used as raw material.

2. Combustible waste may be used as fuel for burning process in the rotary kiln.

3. No secondary waste is generated because cinders of combustible waste will be consumed as raw material.

4. Hazardous materials such as dioxin can be decomposed in the rotary kiln under the high temperature of 1450 ºC.
### Chemical compositions of waste

The reason why by-products and waste can be utilized at cement plants

<table>
<thead>
<tr>
<th>Major natural resources</th>
<th>Composition of major elements (%)</th>
<th>Ordinary Portland Cement</th>
<th>Limestone</th>
<th>Clay</th>
<th>Silica</th>
<th>Coal fly ash</th>
<th>Blast Furnace slag</th>
<th>Sewage sludge</th>
<th>Casting sand</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SiO₂</td>
<td>Al₂O₃</td>
<td>Fe₂O₃</td>
<td>CaO</td>
<td>Total Alkali</td>
<td>Na₂O eq.</td>
<td>SiO₂</td>
<td>Al₂O₃</td>
<td>Fe₂O₃</td>
</tr>
<tr>
<td>Ordinary Portland Cement</td>
<td>20~23</td>
<td>3.8~5.8</td>
<td>2.5~3.6</td>
<td>63~65</td>
<td>0.3~0.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limestone</td>
<td>~4</td>
<td>~2</td>
<td>~2</td>
<td>47~55</td>
<td>~0.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clay</td>
<td>45~80</td>
<td>10~30</td>
<td>3~10</td>
<td>~5</td>
<td>2~6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silica</td>
<td>70~95</td>
<td>2~10</td>
<td>~5</td>
<td>~2</td>
<td>0.5~3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>By-products and waste</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coal fly ash</td>
<td>40~65</td>
<td>10~30</td>
<td>3~10</td>
<td>5~20</td>
<td>0.5~20</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blast Furnace slag</td>
<td>20~45</td>
<td>10~20</td>
<td>~5</td>
<td>30~60</td>
<td>0.1~0.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sewage sludge</td>
<td>20~50</td>
<td>20~50</td>
<td>5~15</td>
<td>5~30</td>
<td>1~5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Casting sand</td>
<td>50~80</td>
<td>5~15</td>
<td>5~15</td>
<td>~5</td>
<td>1~5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Clark numbers: O=49.5  Si=25.8  Al=7.56  Fe=4.70  Ca=3.39 ....
Fly- and Bottom-ash recycling on cement production

FY2009
Consumption of waste:
26,290kt/y (451kg/t-cement)
Ref.: Japan Cement Association

Limestone
Silica Clay
Iron slag

Drying
Grinding
Blending

Raw
material

Dust-collector

Clinker

Fly ash
By-product
gypsum

Gypsum

Cement

Milling Mixing

Organic Waste:
Waste plastic
Waste oil

Coal

Rotary Kiln

Massive waste:
Sludge
Sewage sludge
Tires
MSW

Clinker cooler

Bottom ash
Other waste materials

Fly ash
Cement industry as an MVP of recycling

Approximate 26 million tons of industrial waste including 6 million tons of coal fly ash was recycled in cement industry in 2009

Usage of coal fly ash

Usage of waste tires

References: Japan Fly Ash Association and Japan Automobile Tyre Manufacturers Association
Utilizing by-products and waste

Organic waste is potentially used as fuel

Waste tires

Waste plastics

Wood chips and other biomass

Recycled oil
Key technology of bypass system

Enables to utilize respectively inorganic waste as raw material and organic waste as fuel, and to recover minor elements
Waste to Resources on MSW management

Incinerators

Incineration ash

AK (Applied Kiln)

Ash processing

Existing Cement Plants

Eco-cement

Eco-cement Plants

Landfill sites (extension of service life)

Development of Community

Cement & Concrete

2013 © TAIHEIYO CEMENT
AK (Applied Kiln) System

Hidaka City:
Population 50,000
MSW 15,000 ton/y

Crushing and separating

Aerobic bio-digester

Cement production line making use of digested MSW

Saitama Plant, TCC
Ash processing systems

Bottom Ash Processing System (50,000 t/y)

Fly Ash Washing System (15,000 t/y)

Kumagaya Plant, TCC
Eco-cement plant

One third of MSW in Tokyo has been recycled as Eco-cement since 2006. Tokyo Metropolitan Government has constructed the plant in their landfill site and operation has been commissioned to TCCs subsidiary.

- Input MSW (as incineration ash) 300t/d
- Output Eco-cement 430t/d
Conclusion

1. Coal fly ash generated at thermal power plants can be recycled as alternative clay raw material in large quantities and continuously.

2. The cement manufacturing process with advanced quality and process controls enables to recycle by-products and waste generated by other industries as alternative raw material and fuel.

3. By means of installing Chloride bypass technology, the cement plant can recycle municipal solid waste (MSW) and its incinerated ash as raw material.

4. Taiheiyo Cement has accumulated advanced technologies and experiences related environment as mentioned above and energy efficiency as well, and intends to consult with possible customers and to provide such technologies.

Thank you for your attention.
Баярлалаа !
Thank you for your attention
Locations of Domestic Plants

Direct operation plant
Subsidiary and Affiliate
Total production capacity: 21,067 kt/y

Kamiiso 3,829
Ofunato 2,032
Kumagaya 2,027
Saitama 1,470
D.C. 1,199
Myojo 1,763
Tsuruga 677
Fujiwara 2,326
Oita 5,744
Recycling systems clustered on cement industry

[Diagram showing various waste sources and their relationship to cement production]
Reducing CO$_2$ Emission by utilizing waste as fuel

http://www.cembureau.be/Documents/Publications/
Alternative_Fuels_in_Cement_Manufacture_CEMBUREAU_Brochure_EN.pdf
Utilizing by-products and waste

Transition of ratio of waste derived fuel

Reference: Japan Cement Association

![Graph showing the transition of ratio of waste derived fuel from 2004 to 2009. The y-axis represents the ratio of fossil energy, ranging from 90% to 100%, and the x-axis represents fiscal years 2004 to 2009. The graph shows a decrease in fossil energy and an increase in waste derived fuel over the years.]

- 2004: 99.7% Fossil Energy, 0.3% Waste Derived Fuel
- 2005: 99.5% Fossil Energy, 0.5% Waste Derived Fuel
- 2006: 98.0% Fossil Energy, 2.0% Waste Derived Fuel
- 2007: 96.6% Fossil Energy, 3.4% Waste Derived Fuel
- 2008: 96.1% Fossil Energy, 3.9% Waste Derived Fuel
- 2009: 92.6% Fossil Energy, 7.4% Waste Derived Fuel

Waste derived fuel
Fossil Energy
Technical configuration of AK System

Garbage trucks

MSW

1st day
Garbage bags tear and fragment

2nd day
Aerobic digestion quickly develops

3rd day
MSW turns cement raw material and fuel

Digested MSW

Crushing and separating

Feed to rotary kiln

Bio-digester
Fly ash processing system

- From incinerators
- Dissolution tank
- Belt filter
- Filtrate
- Filter Cake
- Rotary kiln
- Sewage
- CO₂ reactor
- Sand filter
- Hg remover
- Filter cake
- Fly Ash
- Liquid
- Gas
Advantages of Eco-cement

✓ More ash can be recycled

Approximately 50% or more of incineration ash and less natural limestone can be used as raw material.

✓ Standards provide easy use of Eco-cement

Eco-cement is regulated in JIS (Japanese Industrial Standards), and can be used easily for practical purposes.

✓ Heavy metals can be recovered

Some of heavy metals, such as Cu, Pb and Zn can be recovered from collected dust.