Waste Management Technologies in Japanese Cement Industry
- from Manufacturing to Ecofacturing™ -

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On October 1, 1998, Taiheiyo Cement Corporation (Taiheiyo Cement) was formed through the merger of two major Japanese cement manufacturers, Chichibu Onoda Cement Corporation and Nihon Cement Co., Ltd. Both companies have histories of over 100 years. In Japan, Taiheiyo Cement has eight cement plants and five subsidiary cement companies, whose total annual production capacity is over 30 millions ton and total domestic cement market share is about 40%. In overseas, Taiheiyo Cement has eight cement plants - three in China, three in USA, one in Vietnam and one in the Philippines. Taiheiyo Cement also operates several cement grinding plants overseas. And Taiheiyo Cement is now co-managing SsangYong Cement, the biggest cement manufacture in Korea.

1 Introduction
Taiheiyo Cement has been supplying essential and fundamental materials for the construction of social infrastructure and contributing to the creation of an affluent society for over a century. Recognizing that the cement industry consumes large volumes of natural resources and energy, Taiheiyo Cement has pursued not only quality, but also the highest levels of productive efficiency in the world.

Taiheiyo Cement believes that the cement industry will play in the 21st century as a part of an environmentally conscious society, and Taiheiyo Cement will actively contribute to the creation of a resource recycling society and conservation of the global environment.

2 Industrial Cluster with Cement Industry

Zero emissions activities are the efforts of eliminating waste emissions from human society into the natural environment. Learning from the sustainable cycles (ecosystems) that exist in the natural world, it is possible to create industrial clusters that link the production processes of various industries. Material that was once considered waste will be reincarnated as "new resources" bringing society closer to the realization of a zero emissions society. All raw materials procured from nature will be used either in final products or as value added raw materials for other industries or production processes. By networking industries and reorganizing clusters, wastes can be eliminated. This is a society that will more effectively use materials produced by the earth (natural resources), thus reducing the burden on the global environment.

The cement production process has the special characteristic of being able to use large volumes of waste and by-products as raw materials and fuel. The Japanese cement industry produced 82 million tons of cement in 2000 and used 27 million tons of waste and by-products as alternative raw materials and fuel. Currently, the cement industry receives several hundred types of alternative raw
materials and fuel from dozens of industries, and utilizing wastes in this way, the cement industry can be seen as the nucleus of an industrial cluster. Furthermore, when thinking of the cement manufacturing process as a means to process waste, it has the special characteristics of "being able to safety break down dioxins and other toxic materials at high temperatures" and of "producing no new wastes". The process can make the building of new incineration facilities and new landfill sites unnecessary. Taiheiyo Cement has also begun accepting sewage sludge and municipal waste incineration ash as alternative raw materials and fuel, and furthermore, has started a new type of cement manufacturing (Ecocement Plant) that aims to use waste materials more effectively.

3 Utilization of Industrial Waste

The Japanese cement industry has been accepting wastes and by-products from other industries as raw materials and fuel for cement production since it began producing cement. Over 100 years of efforts toward recycling have established the foundation of the environmental research and development, the fruition of which will enable us to receive more alternative raw materials and fuels from other industries. Table 1 shows the amount of waste utilized in the Japanese cement industry, and figure 2 shows a flow of various kinds of waste in the cement plant.

1. Blast Furnace Slag

Since the dawn of its inception, the Japanese cement industry has use large volumes of blast furnace slag from the steel industry as raw material or cement addition. However, in recent year, there has been an increase in coal ash use and a corresponding gradual decrease in blast furnace slag use in cement. However, its use in other related areas, such as a material for concrete aggregate, is increasing.
Table 1  Amount of waste utilized in the Japanese cement industry at 2000.

<table>
<thead>
<tr>
<th>Waste</th>
<th>Utilization</th>
<th>Weight '000 ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blast Furnace Slag</td>
<td>Raw Material, Mixing Material</td>
<td>12,162</td>
</tr>
<tr>
<td>Coal Ash</td>
<td>Raw Material, Mixing Material</td>
<td>5,145</td>
</tr>
<tr>
<td>By-product Gypsum</td>
<td>Raw Material, Additive</td>
<td>2,643</td>
</tr>
<tr>
<td>Non-iron Coal from Mine</td>
<td>Raw Material, Fuel</td>
<td>1,500</td>
</tr>
<tr>
<td>Revolving Furnace Slag</td>
<td>Raw Material, Fuel</td>
<td>795</td>
</tr>
<tr>
<td>Sludge etc.</td>
<td>Raw Material, Fuel</td>
<td>1,906</td>
</tr>
<tr>
<td>Soot &amp; Dust</td>
<td>Raw Material, Fuel</td>
<td>734</td>
</tr>
<tr>
<td>Molding Sand</td>
<td>Raw Material, Fuel</td>
<td>477</td>
</tr>
<tr>
<td>Used Tire</td>
<td>Fuel</td>
<td>323</td>
</tr>
<tr>
<td>Waste Oils</td>
<td>Fuel</td>
<td>359</td>
</tr>
<tr>
<td>Spent Activated Clay</td>
<td>Fuel</td>
<td>106</td>
</tr>
<tr>
<td>Waste Plastics</td>
<td>Fuel</td>
<td>102</td>
</tr>
<tr>
<td>Others</td>
<td>Raw Material, Fuel</td>
<td>433</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>27,360</td>
</tr>
</tbody>
</table>

(2) Coal Ash

Large volumes of coal ash from coal-fired thermal power stations are continually used as a raw material or cement addition.

Then, to promote the effective use of fly ash, Taiheiyo Cement has developed products that mixtures of fly ash and cement. By supplying mixture products that meet user’s needs, Taiheiyo Cement are extending the market of coal ash to construction and engineering materials and fillers.

And moreover, Taiheiyo Cement has begun developing a high strength artificial aggregate, and has established manufacturing technology to produce it from coal ash. The high strength artificial aggregate is a non-foamed, lightweight aggregate made by kiln burning beads of coal ash. Because it is both highly strong and resistant to water absorption unlike previous artificial lightweight aggregates, it is expected to be useful in bridge and high-rise construction.

(3) By-product Gypsum

The Japanese cement industry accepts by-product gypsum from other industries and uses it as a raw material for cement and gypsum boards. Although cement production has been decreasing, by-product gypsum use is increasing as an alternative to natural gypsum.

(4) Used Tires

Used tires are considered to be difficult to recycle and the illegal dumping of used tires is a serious problem being faced by our society. Taiheiyo Cement is utilizing used tires as an auxiliary fuel in the cement manufacturing process. The high burning temperature in the kiln eliminates the possibility of air pollution from processing of the tires. In addition, the metallic elements in the tires are incorporated as a necessary ingredient in the cement itself and no secondary waste is created.
Fig. 2 Flow of utilization of various kinds of waste as alternative raw materials and fuel in the cement plant.

(5) Used Pachinko Machines

The pachinko industry in Japan generates about 3 million used machines annually. Because pachinko machines are composites of wood, plastic and metal, it is difficult to dispose them at general incineration plants. Taiheiyo Cement has established a processing method for used pachinko machines in cooperation with major pachinko machine manufacturers and together are promoting the recycling of these machines. Taiheiyo Cement also plans to start the recycling of used slot machines.

(6) Waste Plastics

Taiheiyo Cement accepts a wide variety of plastics such as defective products and process scraps from the plastic processing industry. In the cement plant, the waste plastics are reduced to specified sizes in crushers and are recycled as a safe and efficient cement kiln fuel.

4 Utilization of waste from local communities

The large volume of waste generated from daily life of communities is increasing disposal costs born by municipalities and is causing shortages of landfill space. To solve these problems, development of new recycling technologies is urgent. Taiheiyo Cement is contributing to the solution of these problems by using household wastes in cement production.

(1) Incinerated Ash of Municipal Waste

In 1998, in conjunction with Kumagaya City in Saitama Prefecture, Taiheiyo Cement developed a system to utilize ash and residue emitted from municipal waste incinerators as a raw material for
the production of Portland cement. Previously it was believed difficult to convert ash from incinerators into a cement raw material owing to the high chloride concentrations. However, this has now been made possible through the development of the ash washing process.

The ash washing process uses water to remove the majority of the chlorides and was put into operation in July 2001, after a 12-month trial run at the operational cement plant.

Today, the system can convert 63,000 tons of incineration ash annually. This incineration ash, gathered from waste facilities in the northern region of Saitama Prefecture, would previously have been sent to landfill sites.

(2) Municipal Solid Waste (MSW)

In 1999, Taiheiyo Cement began development of a system to utilize municipal solid waste (MSW) as collected, without prior incineration. In this system, MSW is placed into a rotary digester and the waste is aerated and fermented for several days. After fermentation the MSW converts into a homogeneous, stable product that can be easily handled and sorted. It is then moved to an adjacent cement kiln where it is used as raw materials and fuel in cement production.

This facility was established at the Saitama plant at Hidaka City, and the proving operation began in March 2001 to effectively process 15,000 tons annually of MSW from Hidaka City, where the plant is located. Taiheiyo Cement is going into a fully-fledged business in the latter half of fiscal 2002.

(3) Water Purification Sludge

Today much of the sludge generated from water supply facilities such as purification plants is landfilled. Taiheiyo Cement collects this sludge and uses it as a raw material for cement.

(4) Sewage Sludge

Sludge discharged from sewage treatment plants has generally been dewatered and incinerated before being sent to landfill sites. However, in recent years, there has been rapid growth in the effective use of sewage sludge as a material resource in cement production. Taiheiyo Cement has also developed various new technologies that convert dewatered sludge cake and incinerated sludge into material resources. Taiheiyo Cement is overcoming the problem of ever increasing volumes of sewage sludge by providing stable and effective treatment methods.

5 Ecocement

Ecocement is a new type of cement produced with recycled materials. The primary raw materials used to produce Ecocement are wastes such as the residue from municipal waste incinerators (ash and soot).

Research for this technology was carried out as part of a national project established under the auspices of the Ministry of International Trade and Industry (currently the Ministry of Economy, Trade and Industry) from 1994 to 1998. The Ecocement technology is the result of joint research
and development between the public and private sector, at the center of which was Taiheiyo Cement. The Ecocement technology is able to efficiently recycle large amounts of waste, which would otherwise be destined for landfill, and is praised for the role it will play in preserving the global environment in the 21st century. The technology is also expected to be instrumental in the environmental revolution. Municipalities around Japan are focusing on the possibilities of Ecocement technology.

In Chiba Prefecture, the technology is being incorporated as a central feature in plans to build an "eco-town". In cooperation with Mitui & Co., Taiheiyo Cement established a joint venture, Ichihara Ecocement Corporation, for the construction of the world’s first full scale commercial Ecocement plant. The plant was commissioned and became operational in April 2001. On an annual basis, the plant is schedule to process 62,000 tons of ash from municipal waste incinerators and around 28,000 tons of industrial waste, including sewage sludge and ash, to generate approximately 110,000 tons of Ecocement.

Additionally, in the Santama region of Tokyo, a joint venture between local municipalities is planning the construction of another Ecocement plant that will produce around 160,000 tons of Ecocement per annum. In doing so, the plant will utilize about 120,000tons of incineration ash.

Ecocement can be used in the same way as Portland cement. Presently it is being used in many familiar applications including concrete products and as a soil stabilization material.

6 Conclusion
Taiheiyo Cement places significant emphasis on the investigation, development and implementation of new technologies or process as important factors in the creation of new linkage of Industrial Recycling Ecosystem. Practical implementation of these technologies has made it possible to utilize a wide range of wastes and by-products in the cement production process.

Taiheiyo Cement will change its part in the highly industrialized society from "Manufacturing" to "Ecofacturing™", toward "Zero Emissions".

"Ecofacturing™" is a coinage associated with "Ecology" and "Manufacturing" and is registered by Taiheiyo Cement Corporation.