Drying sewage sludge with preheated raw meal

Sewage sludge contains a large amount of water, but after drying, a considerable amount of combustible material and ash remains. The cement industry can dispose of this harmlessly and safely using high-temperature waste heat and simultaneously utilise not only the combustible material as fuel but also the ash as raw material. For the efficient utilisation of sewage sludge Taiheiyo Engineering Corp and Taiheiyo Cement Corp have developed a breakthrough drying technology using preheated raw meal.

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In a direct feeding system, commonly adopted to use sewage sludge in cement kilns, sewage sludge including 80 per cent water is directly introduced to the decarbonation zone of the raw meal. However, this approach has the following issues:

- the heat demand required to evaporate the water content is large
- the place at which the water evaporates and the time taken are not constant
- cement production efficiency can decrease due to fluctuating exhaust gas volumes or rapid decreases in burning temperature.

For these reasons, the utilisation of sewage sludge is limited to maintain clinker production volumes and quality. One solution is to dry the sewage sludge using hot gas in a dryer directly. However, this can create other issues since the hot gas, including oxygen, from the dryer must be reheated to more than 800˚C to decompose and eliminate bad odours, leading to heat loss and the risk of explosions.

Preheated raw meal chute and exhaust gas duct

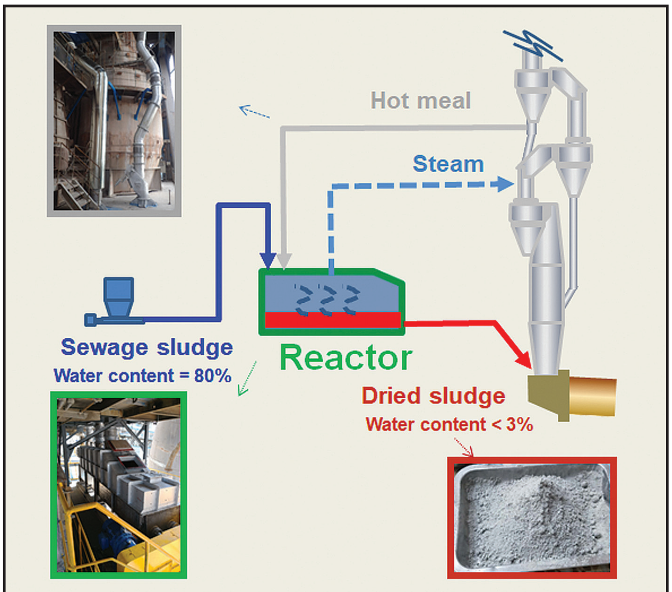

Figure 1: Taiheiyo Thermal Reactor

Another solution could be to dry the sewage sludge by indirect heating with steam, oil or hot gas. However, due to the low heat transfer efficiency a large dryer would be required.

Taking these factors into account, the concepts and targets for Taiheiyo Engineering Corp and Taiheiyo Cement Corp's breakthrough drying technology were set as follows:

- utilisation of sewage sludge: more than 150tpd (per drying reactor)
- high heat transfer
- compact footprint
- minimal adverse effects on cement kiln operation (minimum heat and clinker production loss)

Table 1: performance results for the Taiheiyo Thermal Reactor

	No sewage sludge (benchmark)	Raw sewage sludge (direct feeding)	Taiheiyo Thermal Reactor	
Sewage sludge feeding rate (tpd)	0	90	172	200
Clinker production (tpd)	4370	4141	4370	4162
Increase in heat consumption (kJ/kg clinker)	–	148	98	138

Taiheiyo Thermal Reactor

• system safety.

To meet these parameters it was decided to employ a direct heating method, not with hot gas but using the sensible heat of hot meal extracted from the preheater. In this system the large surface area and high temperature of the raw meal means a high heat transfer efficiency, resulting in a compact dryer.

Following successful laboratory testing and confirmation of performance, commercial equipment was installed in China.

Operational performance

A flow diagram illustrating the Taiheiyo Thermal Reactor is shown in Figure 1 and the operating results are given in Table 1. As Figure 1 demonstrates, sewage sludge (including 80 per cent water) is fed to the reactor by a plunger pump and hot meal is also fed to the reactor by a special fractionating device to discharge hot meal from the preheater cyclone. The sewage sludge is dried in the reactor by the hot meal, resulting in a moisture content of below three per cent. The dried material is then fed to the calciner. The malodorous steam generated in the reactor is not fed to the calciner but to the outlet of the bottom cyclone, therefore avoiding heat loss.

Dried material discharged from the reactor

Table 1 shows the impact on clinker production and heat consumption of sewage sludge processing in a direct feeding system compared to the Taiheiyo Thermal Reactor system. In a direct feeding system, before the installation of the Taiheiyo Thermal Reactor, sewage sludge processing was limited to 90tpd to minimise clinker production loss. With the Taiheiyo Thermal Reactor system, assuming the IDF fan has a sufficient speed margin, more than 200tpd of sewage sludge can be dried in the reactor with minimal clinker production loss and a minimal increase in heat demand. Furthermore, the footprint of the reactor is only 19.8m^2.

Technology comparison

A comparison of typical existing sewage sludge utilisation technologies and the Taiheiyo Thermal Reactor is shown in Table 2. The existing technologies considered are the direct feeding of sewage sludge to the preheater, and drying systems by direct or indirect heating.

In the case of direct feeding system, capital expenditure is lower than any other system. However, the resulting reduction in clinker production is higher than any other system.

Regarding the drying system by direct heating with hot gas, heat loss is higher and, although the kiln can be operated stably, there is the risk of explosion by using hot gas including oxygen.

In the case of a drying system with indirect heating, capital expenditure is higher than any other system.

The Taiheiyo Thermal Reactor has been developed to eliminate such shortcomings.

Conclusion

The performance of this state-of-the-art reactor for drying sewage sludge using hot meal developed by Taiheiyo Engineering Corporation and Taiheiyo Cement Corporation has proven successful. Two Taiheiyo Thermal Reactors have been installed at cement plants to date with further inquiries being processed. ■

Table 2: technology comparison for sewage sludge use in a cement kiln

	System for utilisation of sewage sludge			
	Taiheiyo Thermal Reactor	Direct feeding to preheater	Direct heating by hot gas	Indirect heating by hot gas, etc
Maximum feed rate of sewage sludge	●	x	O	▲
Water content after drying	●	–	▲	▲
Clinker production	●	x	●	●
Energy saving for clinker production	O	x	O	O
Capex for sewage sludge utilisation	O	●	▲	x
Opex for sewage sludge utilisation	O	●	x	x
Construction period	O	●	x	x
Effect on kiln operation	●	x	O	●
Safety	●	●	▲	▲
Heat transfer efficiency	●	x	O	x
Controllability	●	●	O	O

Key: ● = Very good O = Good ▲ = A little poor x = Poor