NO TIME TO WASTE

Yasushi Yamamoto, Taiheiyo Engineering Corporation, explains how a sewage sludge drying system using hot cement raw meal could be an economical, safe, and environmentally friendly solution for the treatment of waste materials.

In recent years, there has been an increasing expectation for the mass treatment of waste materials such as waste plastics, sewage sludge, and biomass to be used in the cement manufacturing process. Meanwhile, ever more strict regulations on air pollution and greenhouse gases are also being applied. To meet these requirements, Taiheiyo Engineering Corporation worked in close cooperation with Taiheiyo Cement group to develop an innovative, economical and safe environmental solution, the 'Taiheiyo Thermal Reactor' or TTR.

This article focuses primarily on the role of this technology in the treatment of sewage sludge.

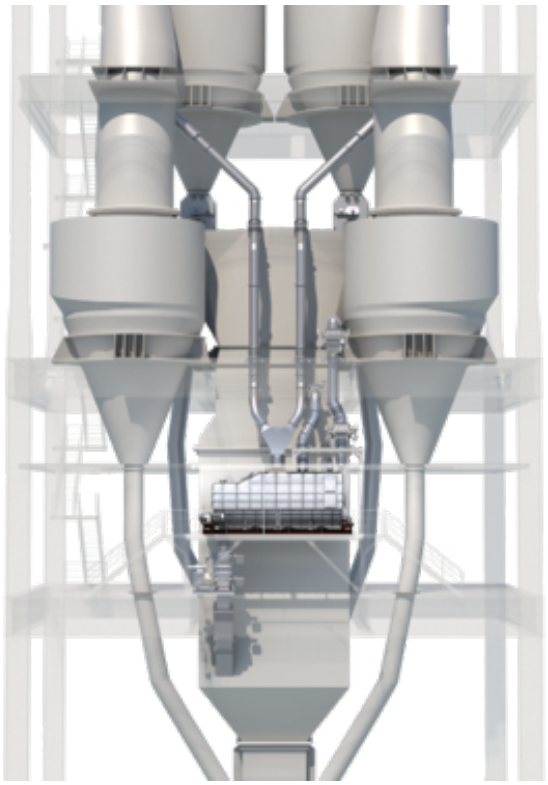

Figure 1. Taiheiyo thermal reactor.

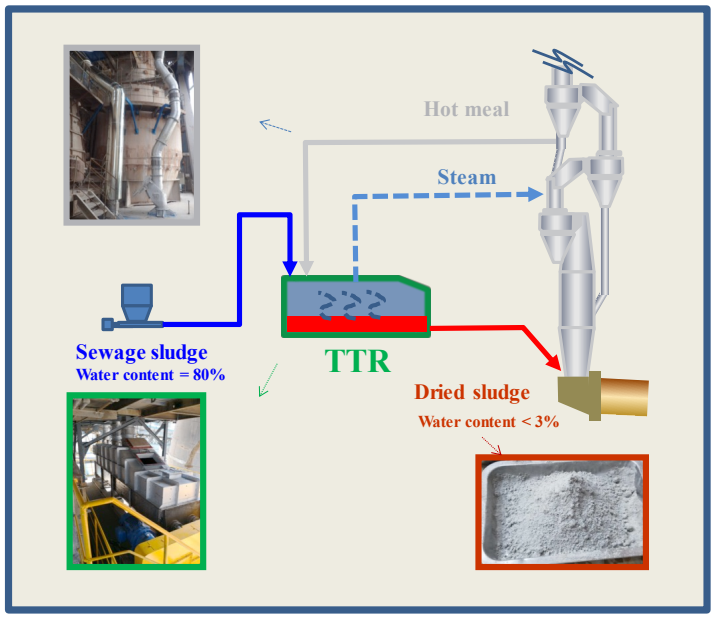

Figure 2. Sewage sludge drying system using TTR.

What is TTR?

TTR is a generic term for equipment (Figure 1) that actively uses hot cement raw meal as the heat source. The equipment acts as a dryer for materials with a high moisture content such as sewage sludge, and acts as a crusher and gasifier for waste plastics.

From waste plastic treatment, CO reduction in the calciner, energy conservation and CO_2 emissions reduction with improved burning efficiency can be achieved.

Sewage sludge treatment methods

Problems with current sewage sludge treatment systems

The most common system for sewage sludge treatment in cement kilns is direct feeding. Sludge with a lot of moisture is fed to the preheater calcining zone without atomising. This simple system requires the least CAPEX, however a large amount of heat is required to evaporate the moisture, and since the water is not atomised, the evaporation time is longer, and an inconstant evaporation time can cause sludge to stick to the calciner inside wall, leading to fluctuations in the volume and temperature of exhaust gas.

In order to cope with this, the fuel ratio on the kiln side must be increased, and the clinker production must decrease more than the increase in water evaporation heat. Therefore, there are restrictions on the amount of sewage sludge to be treated in order to maintain clinker production capacity and quality.

To avoid fluctuations in the volume and temperature of exhaust gas, the sewage sludge air drying method has been developed. However, this method requires the re-heating of exhaust gas containing oxygen from the drying process to over 800˚C; bad odour, heat loss, and risk of explosion are concerns related to this method.

There is also another drying system to heat sewage sludge indirectly with water vapour, thermal oil or hot gas. However, because of its low heat transfer efficiency, it has a large footprint, and a higher CAPEX is required for these systems.

Table 1. Operational results of TTR compared with direct feeding system.

	No sewage sludge (benchmark)	Raw sewage sludge - Direct Feeding	Taiheyo Thermal Reactor	
Sewage sludge feeding fate (t-sludge/d)	0	90	172	200
Clinker production (t-clinker/d)	4370	4141	4370	4162
Increase in heat consumption (kJ/kh-clinker)	-	148	98	138

Commercial plant applications

Before applying the technology to a commercial plant, laboratory tests mixing hot cement raw meal and sewage sludge were carried out and the drying speed was evaluated. The results showed that hot cement raw meal of 700˚C or higher could dry sewage sludge safely, and the large specific surface area of the raw meal enabled fast heat transfer and a short drying time.

Based on these results, commercial equipment was designed.

The system flowsheet is shown in Figure 2. Sewage sludge with 80% moisture (through plunger pump), and hot cement raw meal diverted from the preheater cyclone are both fed to the reactor. Sewage sludge is dried by hot cement raw meal at over 700˚C, and since the inside of the reactor is covered with water vapour and cement raw meal, there is no risk of fire or explosion.

As shown in Figure 3, the moisture content after drying is less than 3%, which could not be easily achieved with existing systems, by setting the temperature of dried sludge at the reactor outlet to more than 100˚C.

Dried sludge is fed to the calciner at the preheater, while water vapour and gas with odour are fed to the bottom cyclone outlet to avoid heat loss caused by the direct feeding method.

Operational control is quite simple; sewage sludge is weighed and fed in a set amount. Diverting the volume of hot cement raw meal is controlled to keep the temperature of dried sewage sludge within the range of 100 – 120˚C.

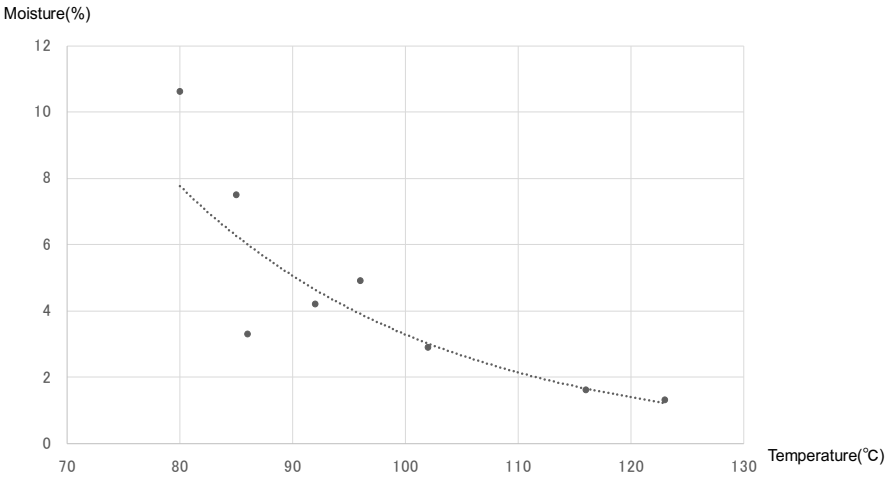

Figure 3. Relation between TTR outlet temperature and outlet material moisture.

Table 2. TTR comparison with existing systems.

	System for utilisation of sewage sludge			
	Taiheiyo Thermal Reactor	**Direct feeding to preheater**	**Direct heating by hot gas**	**Indirect heading by hot gas, etc.**
Maximum feed rate of sewage sludge	Very good	Poor	Good	Quite poor
Water content after drying	Very good	–	Quite poor	Quite poor
Clinker production	Very good	Poor	Very good	Very good
Energy saving for clinker production	Good	Poor	Good	Good
CAPEX for sewage sludge utilisation	Good	Very good	Quite poor	Poor
OPEX for sewage sludge utilisation	Good	Very good	Poor	Poor
Construction period	Good	Very good	Poor	Poor
Effect on kiln operation	Very good	Poor	Good	Very good
Safety	Very good	Very good	Quite poor	Quite poor
Heat transfer efficiency	Very good	Poor	Good	Poor
Controlability	Very good	Very good	Good	Good

The operation result compared with existing systems is shown on Table 1. In direct feeding, before introducing TTR, maximum sewage sludge utilisation is limited to 90 tpd to avoid clinker production decreasing. On the other hand, over 200 tpd sewage sludge could be dried in TTR (volume 10.4 m^3).

If there is a capacity margin in the preheater ID fan, clinker production capacity can be maintained with minimal heat loss.

Comparison with existing systems

Using the operational results, a comparison between TTR and typical existing systems was made – the results are shown in Table 2. Direct feeding systems require smaller CAPEX, however, a bigger production decrease occurs. With a direct heating system using hot gas, stable kiln operation can be achieved, however heat loss, burning and explosions are real concerns when hot gas containing oxygen is used. Indirect heating systems require larger equipment with the highest CAPEX. The advantages of the TTR system as a solution are, therefore, clear in comparison.

Conclusion

The following salient features of TTR were proven through commercial operation:

- High drying efficiency, small footprint equipment.
- No adverse effect on kiln operation.
- Easy operation.
- Increased safety with no bad odour.

Taiheiyo Engineering Corporation developed the sewage sludge drying system with TTR, using hot cement raw meal for drying, in close cooperation with Taiheiyo Cement Group. A second and third TTR have already been installed in the commercial plant and commissioning has been carried out successfully. With its innovative features, cement manufactures in Japan, China, Korea and other countries are now displaying interest in this system.

Reference

1. YAMAMOTO, Y., *International Cement Review*, pp. 79 – 80, September (2020).

About the author

Yasushi Yamamoto is the General Manager of Consulting Service Department at Taiheiyo Engineering Corporation. He has over 30 years of experience at Taiheiyo Cement Corporation for production and numerous R&D projects. After being invited to his current position, he led the development of TTR, a versatile reactor for handling many kinds of waste materials, and is working on searching for its further applications.