Utilization of sewage sludge in Kitakyushu City of Japan

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Abstract: Now, Kitakyushu city has two recycling methods of sewage sludge. The first way is that dried sludge is burned with refuse at incineration facility located by sewage treatment plant. The heat energy generated by the burning is recycled as sources such as electric power source for the plant and the source for sludge drying. Secondly, we've been materializing sludge for cement since 1997. Kitakyushu city is one of the first Japanese cities that introduced this new technology. Both ways are the largest scale ones in Japan. For the next utilization, we are now trying to use sludge as an efficient fuel by further drying process.

Keywords: cement material, sludge incineration, dewatered sludge, fuelization, super power generation

Introduction

In Japan sewage sludge tends to increase every year by the spread of sewers, advanced biological treatment, and change of a lifestyle and so on. Along with it more and more difficulties are coming up in finding appropriate sludge process measures and cost in the treatment. Among municipalities having wastewater treatment plant (WWTP), there is a local body to have a cement company treat dewatered sludge (DS) at its factory, far away 600 km from the city with cargo train transportation. Kitakyushu city introduced Cement Materialization System (CMS) for DS in 1997 and Sludge Incineration System with generally refuse (SIS) at incineration facilities in 1999 instead of sea reclamation and sea dumping disposal. By this shift, we had achieved our objective to utilize the sludge for cement material and power generating to a certain extent. Circumstances surrounding biosolids sludge, however, have been changing these days, as the central government proclaimed biomass strategy for promotion of its utilization in various fields and "the renewable portfolio standard" was enacted in 2003 in favour of sludge energy use in response to the Kyoto protocol enforcement. In line with this movement we have started tackling for the further utilization of sewage sludge as useful biomass resources with intention of reduction of environmental burden on our city toward a recycling society. In this paper we introduce our present state of DS treatment and efforts for future biosolids utilization.

Figure1 shows transition of sewage sludge treatment and volume in Kitakyushu city

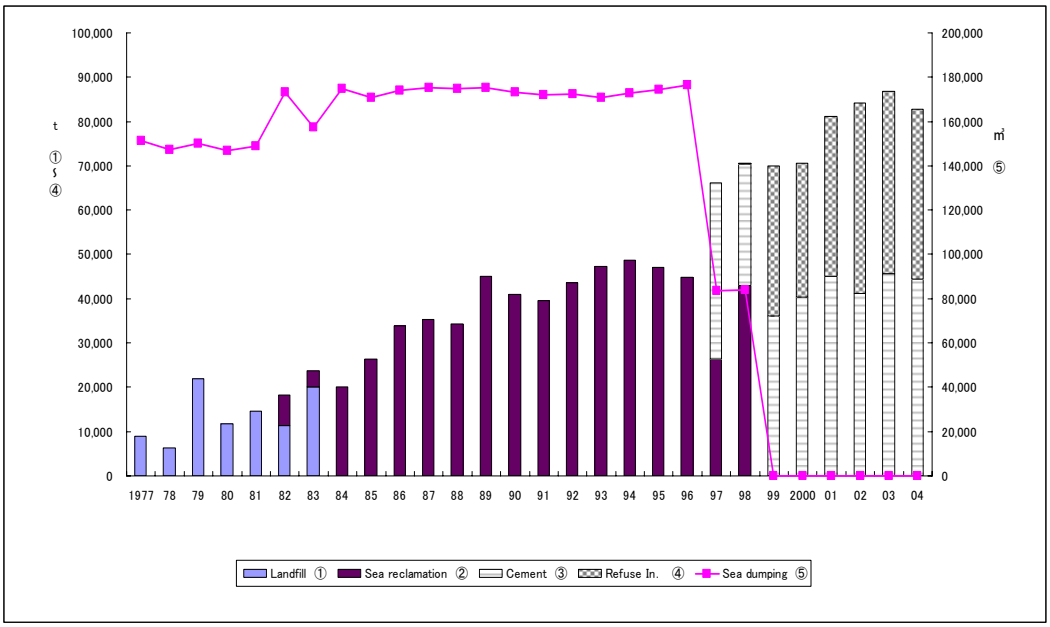


Fig. 1 Transition of the amount of sewage sludge

The dewatered sludge treatment in Kitakyushu city

(1) Outline of present treatment

Kitakyushu city processes DS by two methods called CMS and SIS. The former is the recycling method of the sewage sludge developed by joint team consisting of Kitakyushu city and a cement company and is utilized in other cities now. Incidentally Kitakyushu's case serves as the greatest in quantity in Japan. As for the system of CMS, DS is received with a hopper for exclusive use, and then thrown into a rotary kiln with cement materials, such as limestone, and calcinations process is performed. Then, rapid cooling is carried out with the clinker cooler and it becomes powdered cement. On the other hand, the steam produced by the boilers of SIS is used as dry source for the DS drier at WWTP. The SIS generates electricity, a fraction of which is supplied to the WWTP that pumps up treated water for the incineration facility. In the process, incineration and wastewater facilities synergistically work.

(2)Destination of DS for treatment

There are 5 WWTPs in this city, and they generate approximately 230 t/day of DS. About 60t out of 230t/day is generated from the Hiagari WWTP(HW) with digestion tanks, and the rest (170t/day) is from other WWTPs without digestion process. In addition, half of the daily sludge is turned into cement materials, and the other half is disposed together with regular household refuse at incineration facilities. In order for the sludge to be transformed as cement material, the sludge is transferred to the Mitsubishi Material Corp.'s facilities both at Kurosaki and Kanda. On the other hand, the remaining sludge is supplied to the sludge drier in HW. After drying, the sludge is carried out to the Hiagari and Kougasaki incineration facilities. The destination of DS and its mount of sludge processed are shown in Fig. 2.

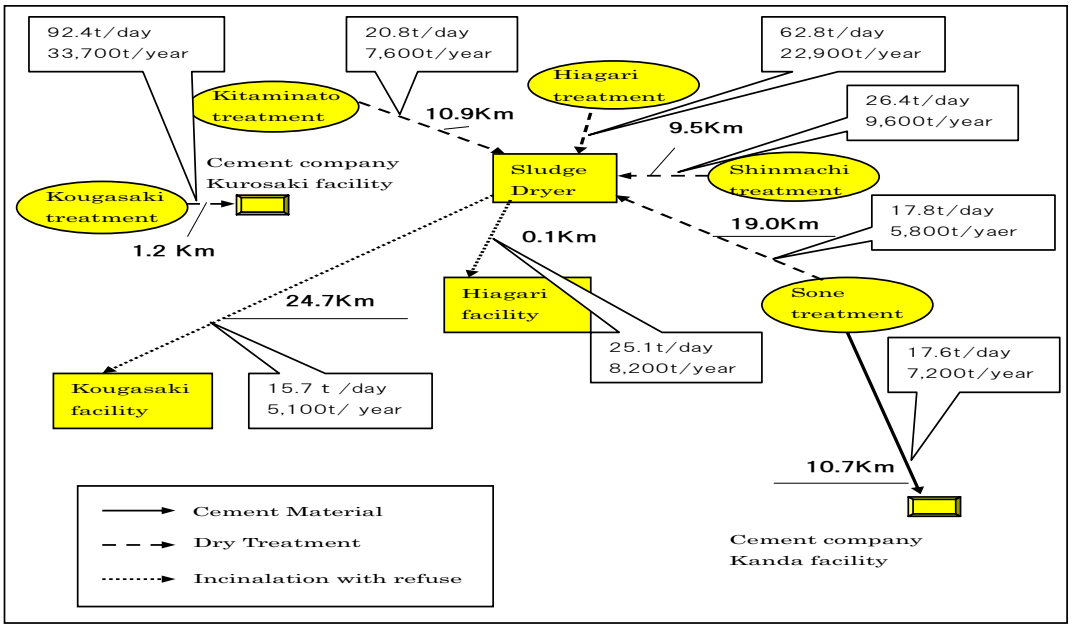


Fig. 2 Destination of DS and its mount of sludge processed

(3) Sludge incineration system with generally refuse (SIS) and power generation

The flow of SIS and diagram of usage of power generated are shown in Figs.3 and 4. As mentioned above, using the steam generated at the Hiagari Incineration facility (HIF) adjacent to HW, DS is dried in a drier currently installed within HW and dried pellets are burned by boilers in HIF and KIF(Kougasaki Incineration Facility). The steam turbines in these facilities generate power using steam attained, and the power generated is supplied to own facility and HW. The surplus of the power is provided to a power company in trade. Thus Energy recycle system has been achieved.

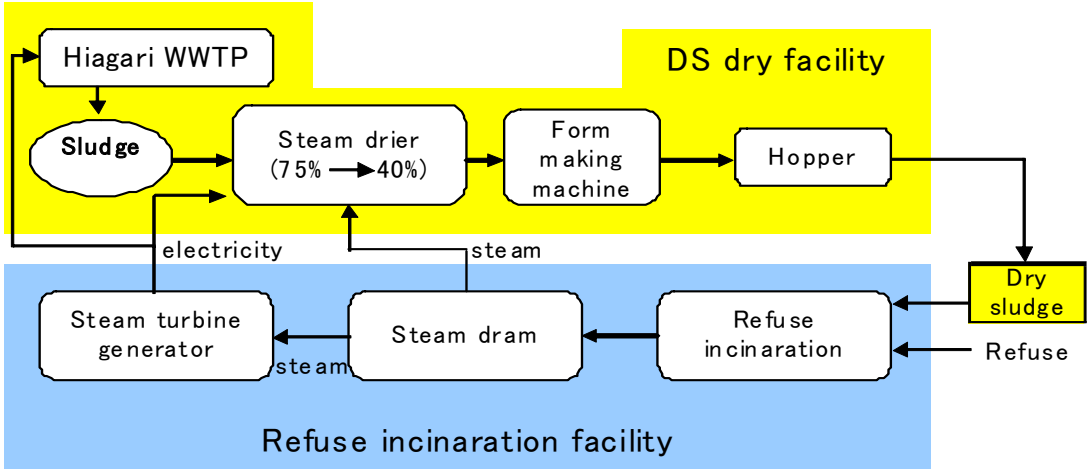


Fig. 3 Energy recycle system of SIS

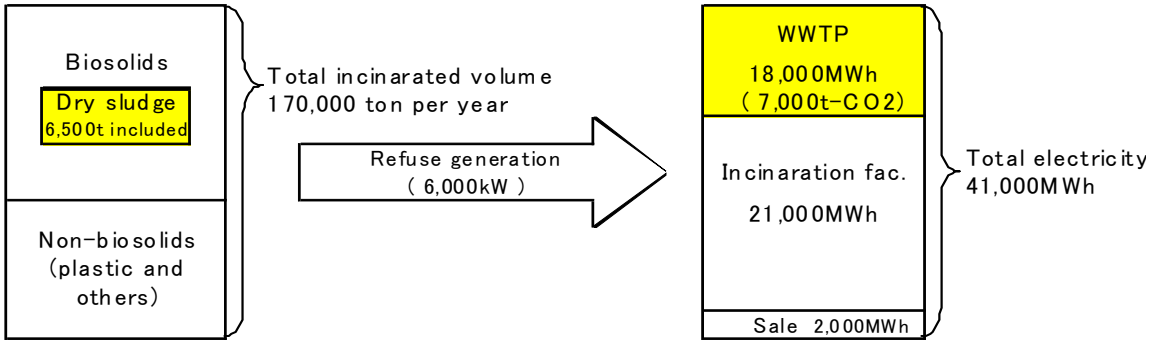


Fig. 4 Hiagari incineration facility's fuel for power and electricity distribution

The most significant point of SIS is that the sludge regarded as mere waste is actually power generation resources. If we compare power generation efficiency of our facilities to 40% of a thermal power plant, 26% at KIF or 10% at HIF is relatively low. However, we can produce the power we need every day without having an electric generating system itself.

Dewatered sludge drier (DSD)

The drier(water evaporation 2×1,800 kg/hr) shown in Fig.5 consists of hopper, sludge feeder, main part of the drier, mixer, form making machine, etc.

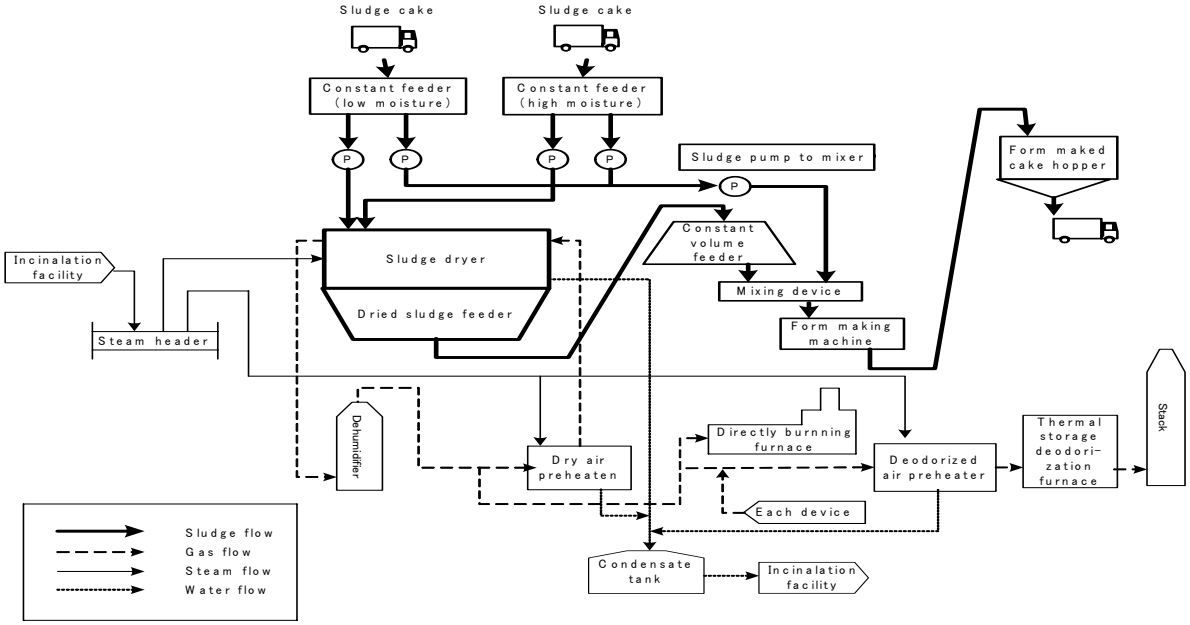


Fig. 5 The flow of sludge dryness facility at HW.

The steam (6t/h) used for drying, which is the surplus steam generated at the adjacent HIF, dehydrates 75% moisture sludge to 40%. The dried pellet is 3cm in diameter and 10cm long. The pellet burns efficiently at the incineration facilities and does not fall out of stoker. In this drying process, original sludge in 75% moisture is mixed with 20% moisture sludge in the drier, and the mixture then turns into 40% sludge. The offensive odour emitted from the sewage sludge is an issue of this drying process, so this plant has three resolutions for deodorization of sludge.

Refuse incineration and Super power generation system

Next, we describe super power generation system (SPGS) which is adopted at KIF. The SPGS uses gas turbine together with steam turbine. As shown in Figure 6, 7 the steam of the refuse incineration boilers is reheated by high temperature exhaust gas from gas turbine, which is placed in the former steps of the steam turbine and consumes city gas as fuel. Reheated steam reaches the high temperature at 370 degrees C and the high pressure at 38 atmospheres absolute. Thus, this combined system, steam turbine and gas turbine, achieves 26% power generation efficiency. Through this system much more electricity can be obtained than conventional systems. This combined system is a maximum scale in Japan.

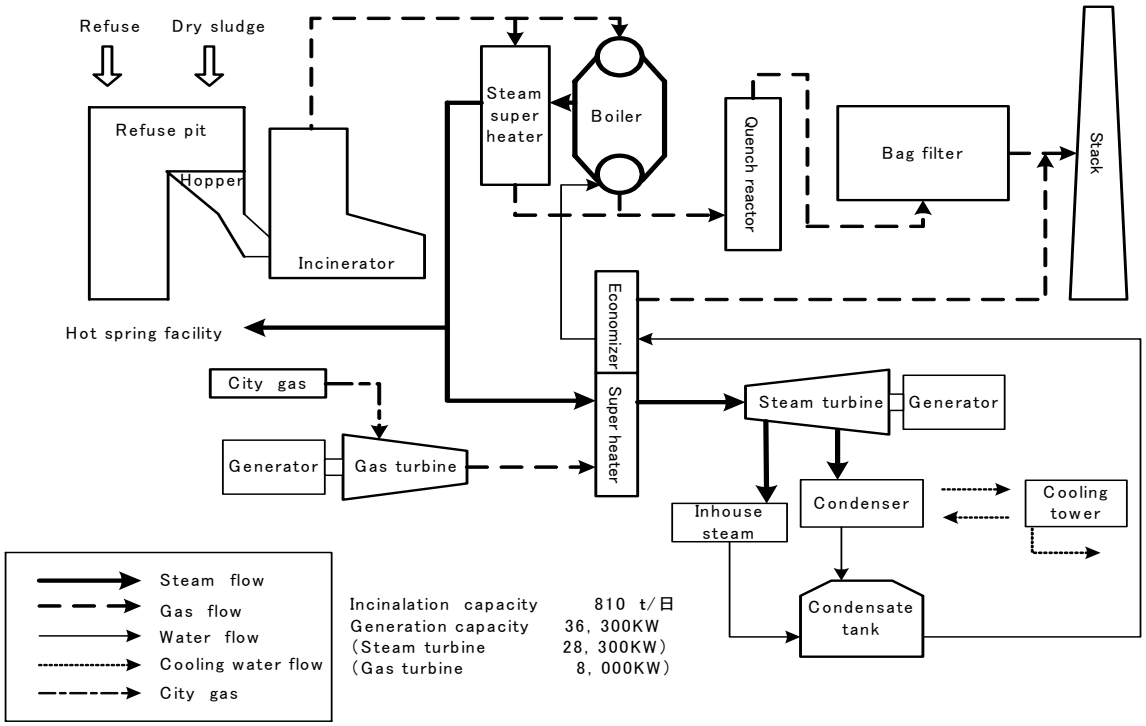


Fig. 6 Power generation flow diagram of the Kougasaki incineration facility

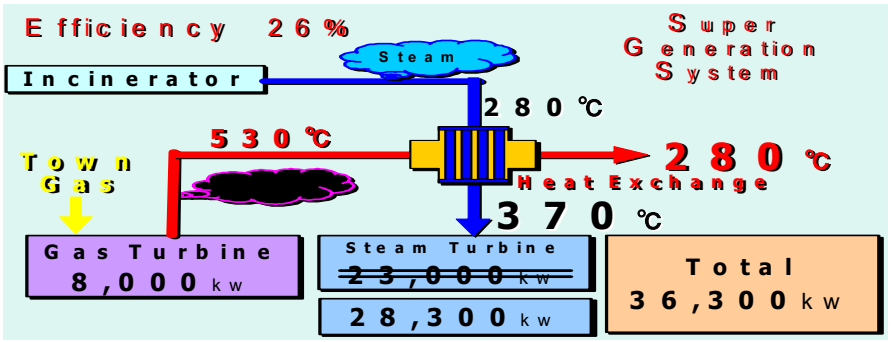


Fig. 7 Super power generation system (SPGS)

At present, one of three refuse incineration facilities in Kitakyushu City is under reconstruction to introduce gasification melting furnace (the Moji incineration facility shown in Fig. 8). The power generation efficiency of this facility is 20%, and it is 10% higher than HIF or conventional ones. In order to achieve higher power generation efficiency, we expect to use this new facility instead of low efficiency facility in HIF.

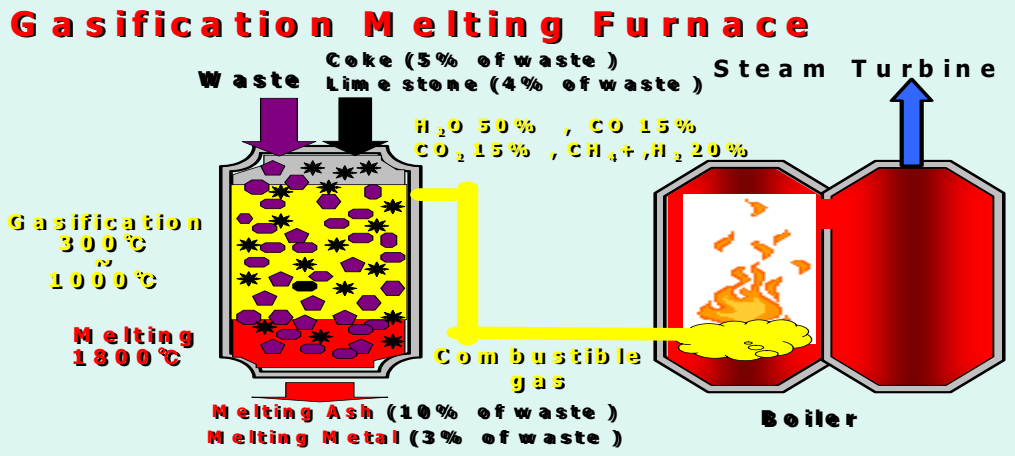


Fig. 8 Gasification melting furnace power generation at new Moji incineration facility

(4) Cement materialization system

The system of cement materialization of DS in Kitakyushu city has following features.

- Because we directly supply the DS into a cement manufacturing process, everything can be effectively utilized as cement materials. Thus, it does not waste any DS. Moreover, the organic matter included is used as substitution of calcinations fuel.
- Since the DS is thrown in a kiln at a temperature of 1,500 degrees C, it is decomposed completely. Thus, no odour emission occurs.
- Cement materialization business in a scale of 40,000t DS per year is at the national maximum level.
- Since one of the private sector's cement factories is adjacent to Kougaki WWTP, the cost for sludge transportation is low.

Since the limited number of cement companies accepts our sludge, there is no competition in contract. Therefore, we do not have space to quickly response to needs of the present times such as converting to new systems, although the CMS mentioned above has advantages. This is our subject.

Measures of sludge treatment in the future

(1) Subjects on future DS treatment in Kitakyushu city

The following are subjects on DS treatment in Kitakyushu city in coming years.

Correspondence to social situation changes like global warming prevention etc.

From now on, the use of the renewable energy that does not rely on fossil fuel will be further advanced at a worldwide level as promoted by "Kyoto Protocol". Focusing on the sewage sludge, the organic matter in the sludge is assumed to be biomass 100 percent renewable energy. So now we are facing an important transitional period from waste to the valuable thing regarding sewage sludge. Based on this realization, we should take the most appropriate measures for next-generation method for the sewage sludge treatment in Kitakyushu city.

Regarding the reduction of sludge processing expense.

For further utilization of sewage sludge as useful resources, we want to select and introduce methods that cost us the least.

Agreement limit for cement materialization

Present agreement term with the private sector for the materialization is going to expire in 2009. Although it is possible to continue the agreement, we might have to concern about unfavourable sludge acceptance price.

The sludge drier's standard life to 2009

The Hiagari sludge drier was built in 1999 and has been operating for 7 years. The standard life the central government defines is ten years, so the sludge drier will reach the maturity date in three years. If we continuously use the facility after the standard life passes, we must make overall judgment for the maintenance and repairs.

(2) Direction and note in the future sludge treatment

Sewage sludge treatment adviser committee

This city set up "Sewage sludge treatment adviser committee" in August, 2005 by the specialists who belong to universities and a laboratory in the country based on the subjects mentioned above to make use of the sewage sludge as a valuable resource, and to examine a suitable processing method for this city from the viewpoint of reducing the environmental burden of the city. We will do the overall evaluation from the views on an economy, energy consumption, and an environmental aspect, etc. by the end of this fiscal year, and bring the investigation results.

Sludge fuelization

There are several methods of sludge fuelization. Adopting new method, duration of practical use, energy consumption efficiency, global warming prevention as well as economies should be evaluated. So-called dryness, dry granulation and carbonization methods have been practically used inside and outside the country, though some subjects still remain unsolved in other methods. Most of sludge fuelizing methods consume some kind of fuel through a dry process and the carbonization process, etc. in order to create a new fuel. In other words, the fuel used is converted to the biomass fuel. Supposed we do most efficient processing, energy yield by the conversion is 1.5 times energy of the fuel consumption. We should select the processing method and scale considering these things.

Sludge Fuelization verification test

At the Kitaminato WWTP, sludge fuelizing field test has been started since this march. This test employs the Dry Granulation Method. In this method, exhaust gas that comes from the burning of fuel is directly brown against the dry dram with paddles. This method is expected to have high dry efficiency and possible to obtain dry grain in ball with nearly 8 % moisture which has about 17Mj/kg in lower calorific value. So this grain could be an alternative energy source of coal which is consumed at power plants. We will continue this verification test until next march and make a comprehensive assessment on technical reliability, financial aspect, and heat balance and so on. (This test is carried out by Japan Sewage Works Agency and Nippon Steel Corporation.)

Overhaul of dewatered sludge treatment system

During the overhaul of the sludge dryer, sludge is treated in the cement facility. The cost for treatment is included in the present contract. The cement factory has the treatment capacity for the sludge and is always ready to receive the sludge. Considering the future, it will become an important point to secure a way for overhaul. It is difficult to store DS temporally in the process of the sludge treatment because of the odour issue. Kitakyushu City has three refuse incineration facilities, and each has capacity to stock 10 days or more volume of refuse in pit. In addition, total incineration capacity makes one month overhaul of each facility alternately in a year. So considering it, at least three ways might be required to secure the DS treatment in our city.

Bad odour control measures

As mentioned above, drier has two high and one low deodorizer at present. One of high deodorizers was additionally introduced after the construction because people who live in the vicinity of the plant often complained about the bad odour from the drier. In spite of this improvement, even now some complaint is reported from the neighbourhood. For the construction of fuelization facility in the centre of highly populated cities, we need to think about how we can prevent possible odour issue.

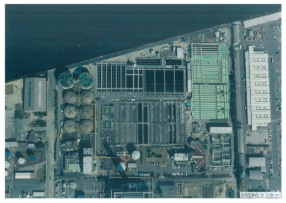
Conclusions

Kitakyushu City proclaimed “A grand design aiming at World Capital of Sustainable Development” in 2004 in which we have 10 basic philosophies. Of those philosophies, reduction of environmental burden, CO2 emission, water and air contamination and others, on our region and earth is included. In adherence with the spirit of it, we consider introducing next generation’s sludge treatment method from the following perspectives.

- Realizing “uniqueness of Kitakyushu city”
- Fuelizing biosolids sludge
- Emphasizing effective and efficient system in energy consumption and CO2 emission.

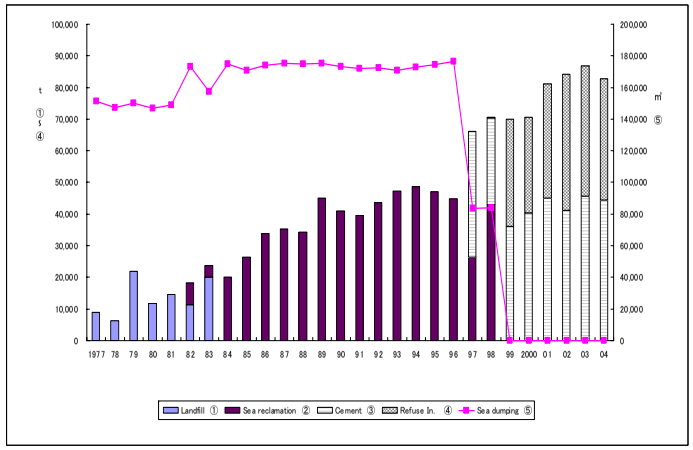
Kitakyushu city experienced severe environmental pollution in 1950s and 60s and finally overcame it through citizen’s movement and cooperation between people, corporations and our government. In this respect spread of sewerage in our city played an important role of the improvement of the environmental situations. Thorough sewage works, we will continue making contributions in a positive manner to resolving local and global environmental problems and fulfil our responsibility as a world citizen in the future.

Utilization of sewage sludge in Kitakyushu City of Japan



Construction Bureau
Sewer Systems Administration Department

Transition of the amount of sewage sludge and treatment



Treatment of sewage sludge (Past)

London Treaty revision enacted in 1996

Past
・sea reclamation (～1998)
・sea dumping (～1999)

Sea reclamation

Sea dumping

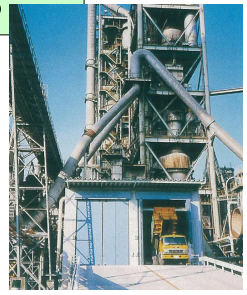
Treatment of sewage sludge (Present)

London Treaty revision enacted in 1996

Past
・sea reclamation (～1998)
・sea dumping (～1999)

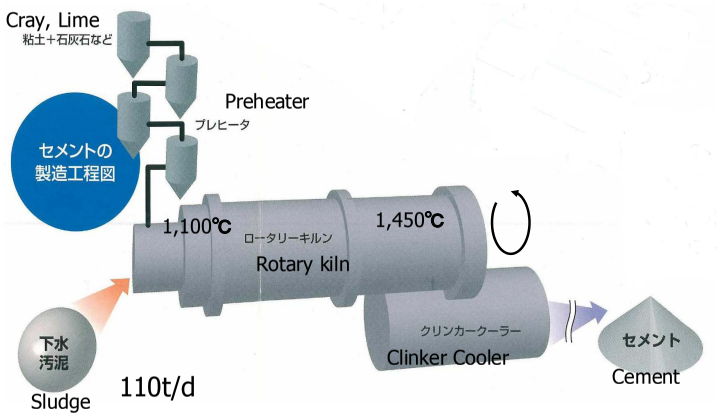
present
・cement materialization (1997～)
・sludge incineration with refuse(1999～)

Sludge incineration



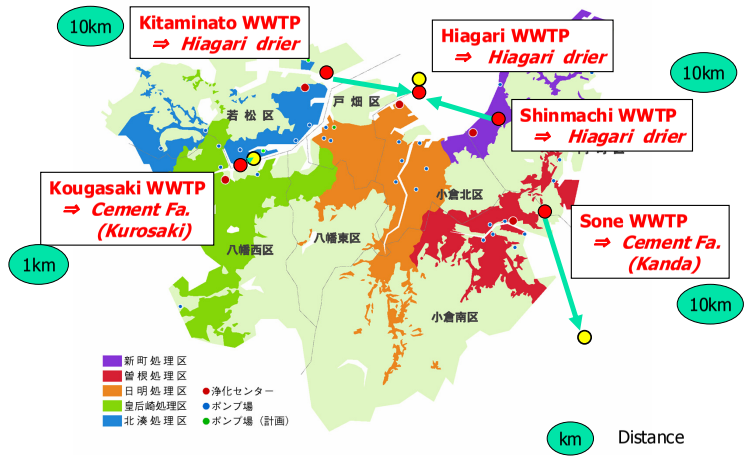
Cement materialization

Cement Material Process

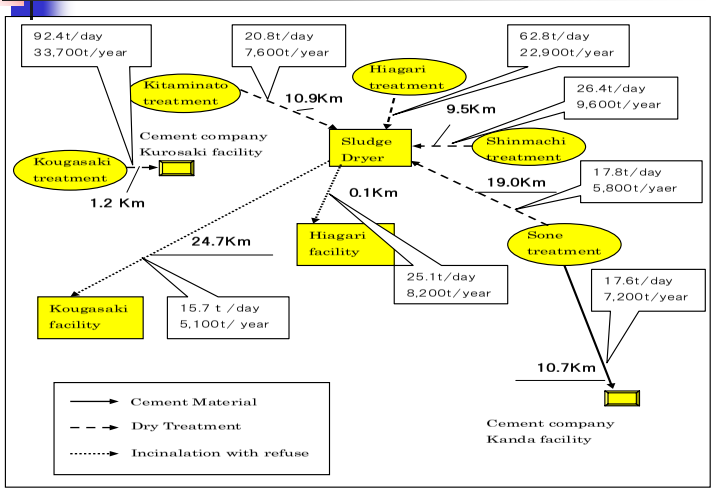


Present state of sludge treatment

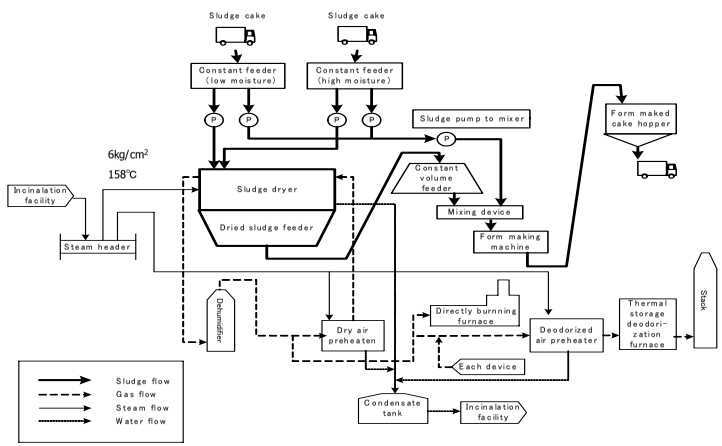
Hiagari dry facility
⇒ *Hiagari I F (0.1km)*
⇒ *Kougasaki I F(25km)*



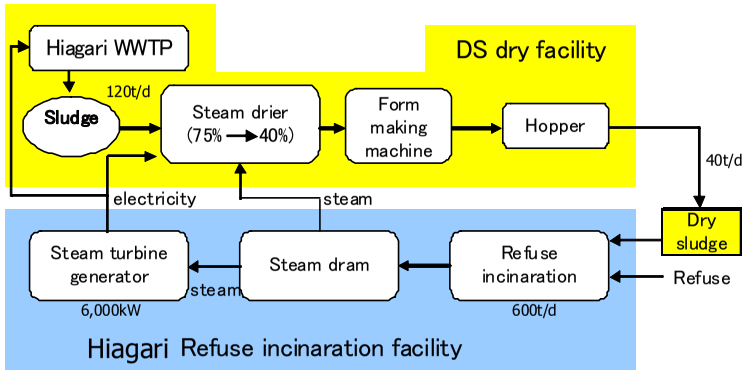
Destination of dewatered sludge



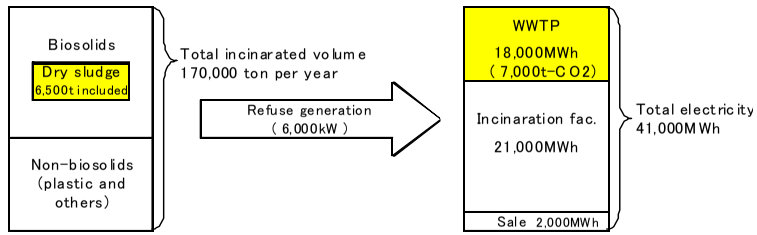
The flow of sludge dryness facility at HW



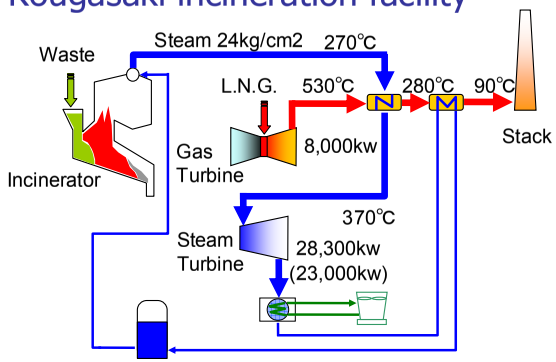
Energy recycle system of sludge incineration with refuse



Hiagari incineration facility's fuel for power and electricity distribution



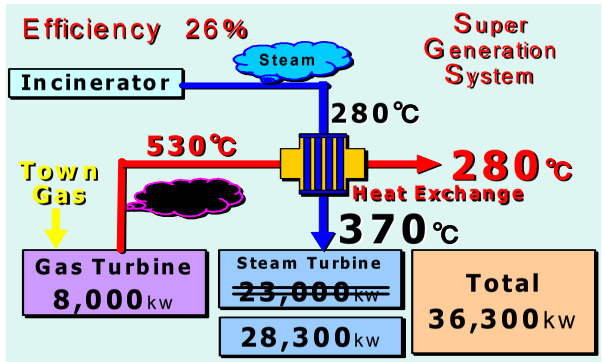
Power generation flow diagram of the Kougasaki incineration facility



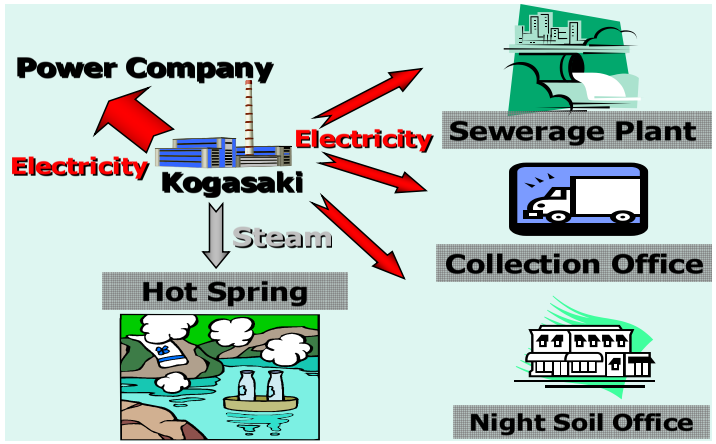
Super Electric Power Generation System in Kougasaki

Total Efficiency 26%

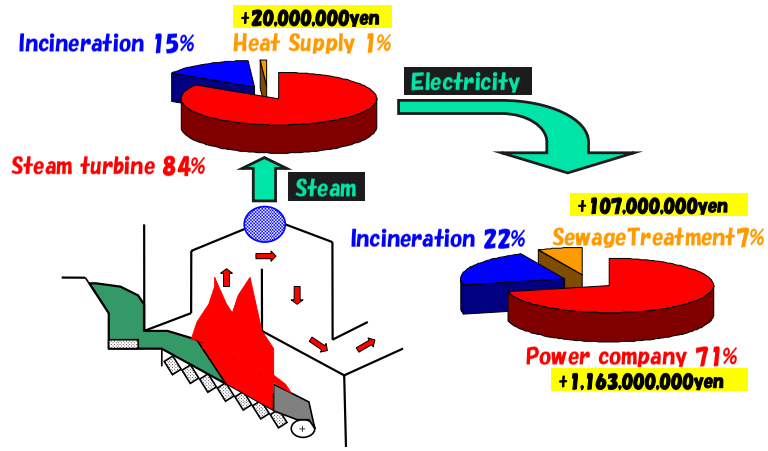
Super power generation system



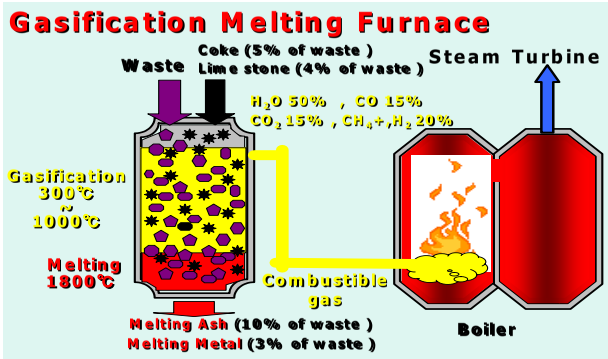
Utilization of Heat



Ratio of steam consumption in Kougasaki



Gasification melting furnace power generation at new Moji incineration facility



High Efficiency (20%) Power Generation

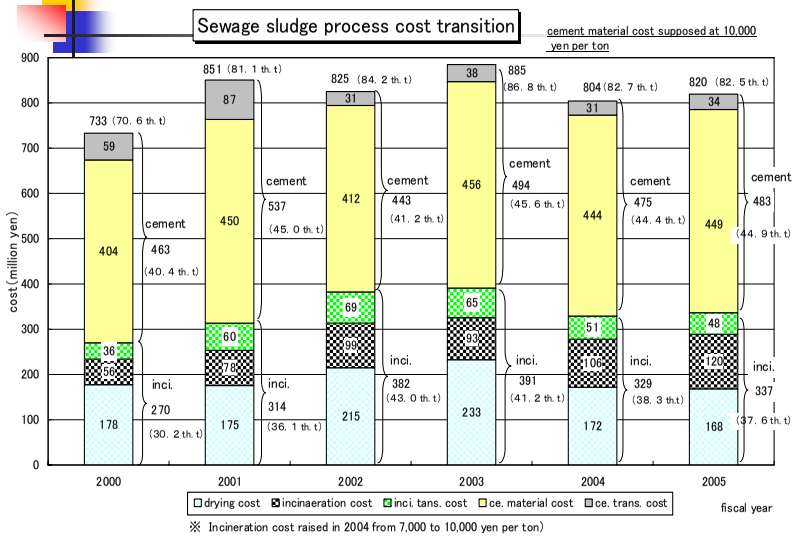
Steam Pressure 40kg/cm2

(Hiagari 20kg/cm2、Kogasaki 23kg/cm2)

Steam Temperature 400℃

(Hiagari 255℃、Kogasaki 370℃)

Power Generation 23,500kw



Subjects for dewatered sludge treatment

- ◆Agreement of cement material（～2009）
- ◆Sludge Drier's standard life（～2009 ）
- ◆Response to social changes on environment like global warming prevention
- ◆Reduction of sludge treatment cost

Transition of sewage sludge treatment

London Treaty revision enacted in 1996

Past
- ・sea reclamation (～1998)
- ・sea dumping (～1999)

present
- ・cement materialization (1997～)
- ・sludge incineration with refuse (1999～

future

Biosolids use、New type of treatment (fuel alternative)

Global environment conservation ····· Social changing ····· global warming prevention

1999 Law concerning the Promotion of the Measures to Cope with Global Warming
2000 Fundamental Law for Establishing a Sound Material-Cycle Society
2003 renewable portfolio standard
2004 "A grand design aiming at World Capital of Sustainable Development" proclaimed
2005 Coming into effect of Kyoto Protocol

Comparison of future sludge process methods

■Sewage sludge treatment adviser committee

■Measures to be considered

- Drier
- Dry granulation
- High temperature carbonization
- Low temperature carbonization

Sludge fuelization verification test (dry granulation method)

Produced sludge grain

Moisture 8%, Reduction rate 1/5, 17Mj/kg

Note for decision of method

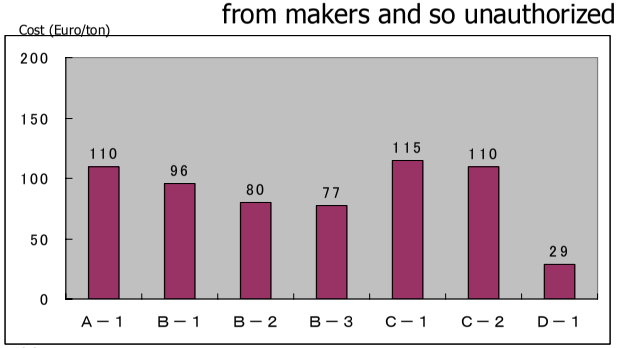
- Overhaul
  How to treat dewatered sludge during overhaul of facilities
- Odour
  countermeasures to control bad odour in urbanized plot----biological, activated carbon deodorizations and others

Objectives

- To adopt efficient system in energy consumption and CO2 emission control
- To utilize sewage biosolid as a fuel
- To realize uniqueness of Kitakyushu city

Cost for future DS treatment in our city

Mere result based on questionnaires
from makers and so unauthorized



Prerequisite

- Transportation cost included
- Overhaul term's process cost included
- Countermeasure cost against bad odour not included
- There would be companies to be able to accept products created