SOCIALIST REPUBLIC OF VIETNAM
Ministry of Industry and Trade (MOIT)

Guideline for Technical Regulation Volume 2

Design of Thermal Power Facilities

Book 8/12

« Coal Ash Handling Facility »

Final Draft

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Table of Contents

List of Tables

List of Figures

List of Photos

List of Acronyms/Abbreviations

AE	Air Entering
ASTM	American Society for Testing and Material
BF	Bag Filter
CAT	Chloride Amine Triaging
CFB	Circulating Fluidized Bed boiler
EP	Electric Precipitator
ISO	International Organization for Standardization
JIS	Japanese Industrial Standard
KHI	Kawasaki Heavy Industry
NOx	Nitrogen Oxide
SHI	Sumitomo Heavy Industry
SOx	Sulfur Oxide

Chapter-1. Comparison between Technical Regulation and Technical Guideline of ash handling facility

The article number of this guideline is shown in the Table-1 contrasted technical regulation with technical guideline for easy understanding.

Table- 1: Comparison between Technical Regulation and Technical Guideline of ash handling facility

Technical Regulation		Technical Guideline	
Article 202.	General provision of ash collection and transportation facility	Article 202.	General provision of ash collection and transportation facility
-1.	General requirement		
		-1-1.	Flow of ash generation on coal thermal power plan
		-1-2.	Amount of ash generation
		-1-3.	Configuration of ash treatment facility
Article 203.	Cyclone ash collection and transportation facility	Article 203.	Cyclone ash collection and transportation facility
-1.	Cyclone ash collection and transportation facility		
		-1-1.	Nature of cyclone ash
		-1-2.	Collection system of cyclone ash
		-1-3.	Transportation system of cyclone ash
		-1-4.	Design requirement
Article 204.	Cinder ash collection and transportation facility	Article 204.	Cinder ash collection and transportation facility
-1.	Cinder ash collection and transportation facility		
		-1-1.	Nature of cinder ash
		-1-2.	Collection system of cinder ash
		-1-3.	Transportation system of cinder ash
		-1-4.	Design requirement
Article 205.	Clinker ash collection and transportation facility	Article 205.	Clinker ash collection and transportation facility
-1.	Clinker ash collection and transportation facility		
		-1-1.	Nature of clinker ash
		-1-2.	Collection system of clinker ash

Technical Regulation		Technical Guideline	
		-1-3.	Transportation system of clinker ash
		-1-4.	Design requirement
Article 206.	General provision of ash collection and storage facility	Article 206.	General provision of ash collection and storage facility
-1.	Gypsum	-1.	Gypsum
-2.	Selection of ash treatment method	-2.	Selection of ash treatment method
Article 207.	Ash classification facility	Article 207.	Ash classification facility
-1.	Method of recovery of fine ash	-1-1.	Classification of ash
		-1-2.	Method of ash classification
		-1-3.	Ash classification facility
Article 208.	Ash storage silo	Article 208.	Ash storage silo
-1.	Design criteria of ash treatment facility	-1-1.	Requirement for ash storage
		-1-2.	Type of ash silo
		-1-3.	Typical system of ash transportation
		-1-4.	Aeration Equipment
Article 209.	Ash discharge facility	Article 209.	Ash discharge facility
-1.	Ash discharge facility and transporter	-1-1.	Ship loader and self unloading carrier
		-1-2.	Loader for jet-pack wagon
		-1-3.	Loader for jet-pack trailer
		-1-4.	Loader of wet ash for dump truck
Article 210.	General provision of ash dump	Article 210.	General provision of ash dump
-1.	General requirement	-1.	General requirement
Article 211.	Off-shore disposal	Article 211.	Off-shore disposal
-1.	Ash slurry discharge pond	-1.	Ash slurry discharge pond
-2.	Effluent treatment from pond	-2-1.	Effluent treatment from pond
Article 212.	On-shore disposal	Article 212.	On-shore disposal
-1.	Recycle of ash	-1.	Recycle of ash
-2.	Final disposal of remaining ash	-2.	Final disposal of remaining ash

Article 202. General provision of ash collection and transportation facility

Article 202-1-1. Flow of ash generation on coal thermal power plant

1. In the coal-fired power plant, pulverized coal is burned in the boiler and the heat energy is converted to electrical energy. Ash particles which are melted by the combustion are suspended inside the hot combustion gases and become fine spherical particles due to decreasing temperature in the boiler outlet, and are collected by the electric dust collector as shown in Fig-1. In generally, this is called the fly-ash. This fly-ash is stored in a dry state in a silo, grain adjustments made by the classifier as formulated or more depending on the application and stored in silos by product.

   Clinker ash are the ash which coal ash particles aggregated to each other caused by combustion in the boiler, porous mass fall into the clinker hopper (water tank) and are deposited , and is crushed to sand after dewatering. After dewatering in a dehydration tank, etc. to adjust the particle by size sieving machine according to the application. In addition, dry without using some type of tank as clinker type hopper, but this is almost like a wet type.

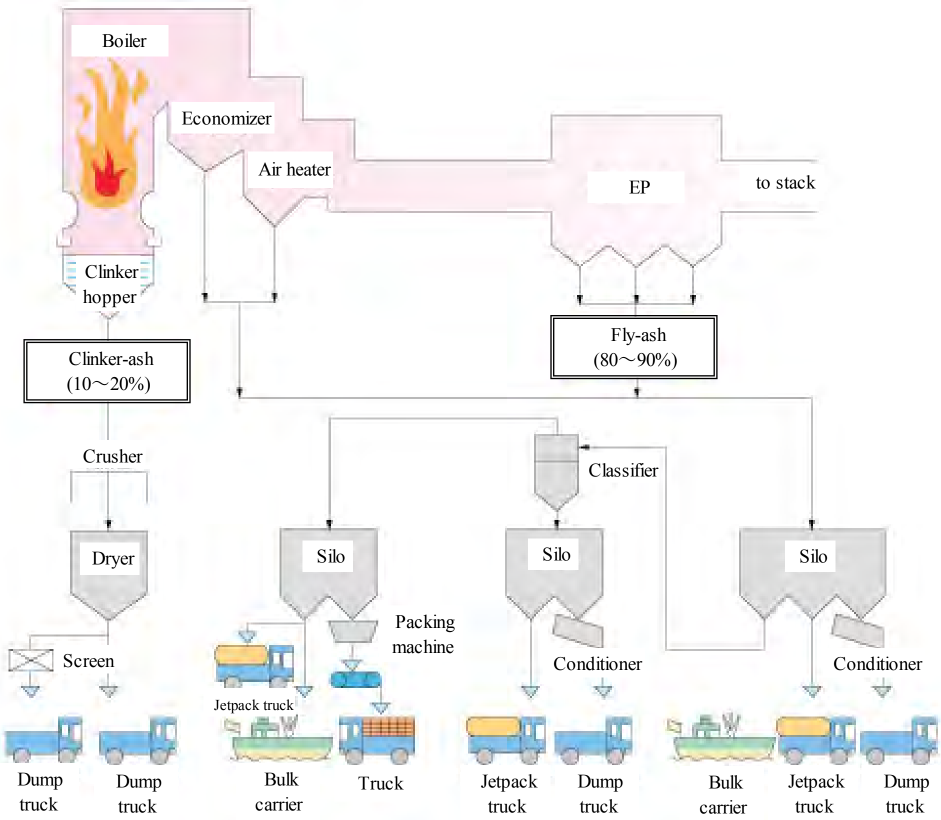


Fig- 1: Flow of coal ash generation from coal-fired power plant

http://www.japan-flyash.com/process.html

Article 202-1-2. Amount of ash generation

1. Typically, when coal is combusted in the boiler, three kinds of ash, the bottom ash (clinker ash) which fall to the bottom, the cinder ash which fall to the economizer hopper scattering along the flue gas duct with combustion gas, the fly-ash which fall to the hopper of air heater or dust collector or be collected are generated. The distribution of each ash hopper is approximately as shown in Fig-2. In addition, 0.1% to 1% of mill-pyrite from the coal is generated in general.

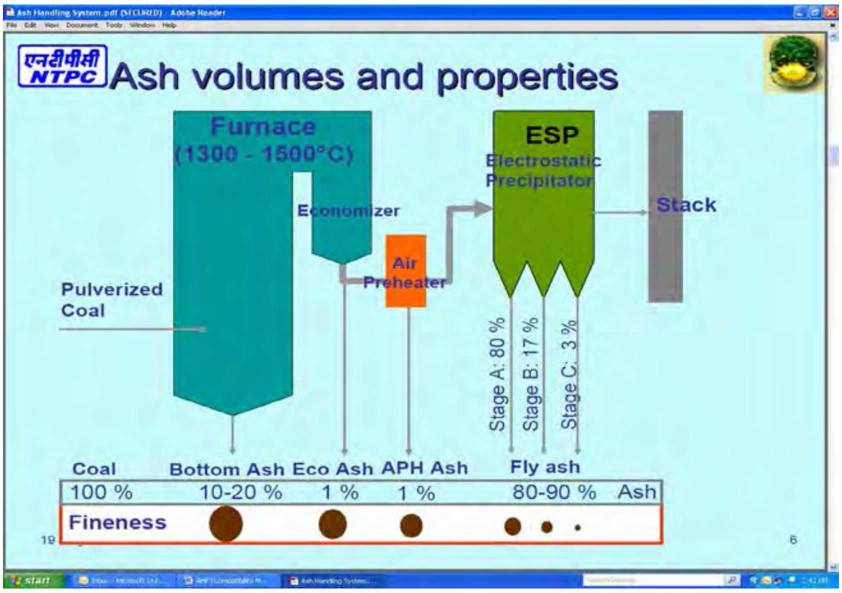


Fig- 2: Balance of coal ash generation

http://thermalpowerplant.files.wordpress.com/2011/04/ashhandllingsystem.jpg

Article 202-1-3. Configuration of ash treatment facility

1. Ash emitted from pulverized coal-fired boiler is divided into the bottom ash (clinker) which falls to bottom of boiler and the fly-ash which is caught, falls to and is stored economizer, air heater and electric precipitator hopper accompanying the combustion gases from the furnace.

   The cinder ash which is collected in the boiler flue gas duct and is relatively coarse may be distinguished with the fine fly-ash which is collected in the electric precipitator. The distribution of each of these ashes in the hopper is shown schematically in Fig-2. The ash handling system is divided into the following two facilities, although there is some variation depending on the final disposal or location of each power plant.

   1) Ash transportation and storage facility

      The transportation facility from where ash generation point to the ash storage facility which is directly linked to the unit including the clinker ash treatment facility, mill-pyrite treatment facility and fly-ash treatment facility.

   2) Ash disposal support facility

      The equipment for disposal to in-premise ash pond, shipment equipment to off-premise and classification equipment, etc. is referred to ash disposal supporting facility.

Article 203. Cyclone ash collection and transportation facility

Article 203-1-1. Nature of cyclone ash

1. Chemical property

Coal ash is mainly composed of silica（SiO_2）and alumina（Al_2O_3）, and accounts for 70~80% of the total of these two minerals. Others are the small amount of ferric oxide（Fe_2O_3）, magnesium oxide（MgO）, calcium oxide （CaO） and the like as shown in Table-2.

Table- 2: Chemical composition of ash

	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO
Fly-ash	40.1 ~ 74.4	15.7 ~ 35.2	1.4 ~ 17.5	0.2 ~ 7.4	0.3 ~ 10.1
Clinker ash	51.6 ~ 64.0	17.3 ~ 26.9	4.2 ~10.9	1.0 ~ 2.6	2.3 ~ 8.8

Remarks: The variation depends on the type of coal.

Reference: P-72 of Journal (No.609: June/2007): TENPES

2. Physical property

(1) Fly-ash

The main component of fly-ash is “silica” and “alumina” like soil, when mixed with cement, hydration of cement (cement react with water to create a new compound) is generated during the “calcium hydroxide” by reaction with improved durability and water resistant properties. Also, fly ash is used in the field of civil engineering and building work, because of the reason of its improved flowability of the concrete when using it mixed with concrete, since it has small spherical particles as shown in Photo-1 and 2.

Photo- 1: Fly-ash

http://intertrans.en.busytrade.com/products/info/930706/Fly-Ash-From-Coal-Thermo-electric-Plant-In-Vietnam.html

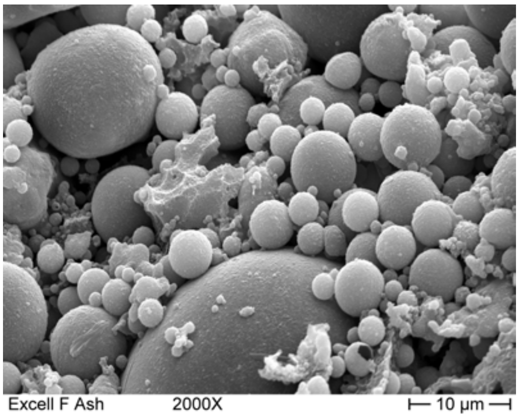


Photo- 2: Fly-ash particle

http://www.pmetlabservices.com/library/Fly%20Ash/index4.html

The standard distribution of particle size for test powder as shown in Photo-3, 4 is stipulated is stipulated in Table-3. In addition, the relation between the percentage passing weights vs. particle size is shown in Fig-3.

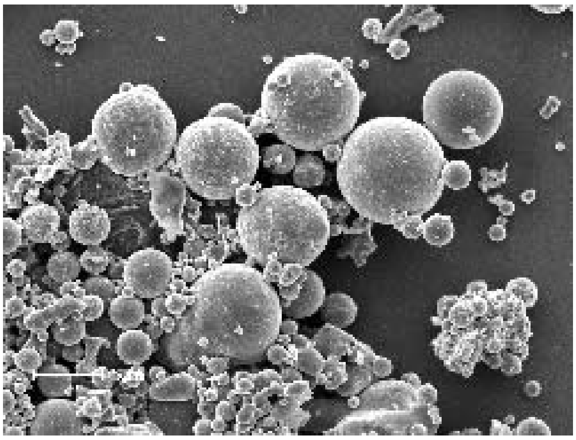


Photo- 3: Test powder type JIS 1-5

http://www.appie.or.jp/testpowders/details/img/ph07.jpg

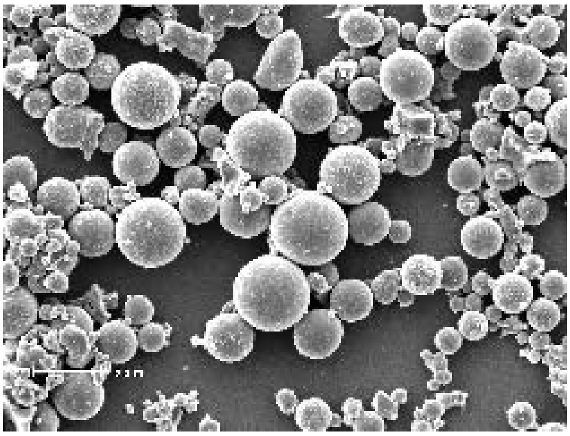


Photo- 4: Test powder type JIS 1-10

http://www.appie.or.jp/testpowders/details/img/ph07.jpg

Table- 3: Distribution of particle size

Particle size (μ)	Over-size (wt %)	
	Type JIS 1-5	Type JIS 1-10
2	—	82 ± 5
4	—	60 ± 5
5	84 ± 5	—
8	—	22 ± 5
10	60 ± 5	—
16	—	3 ± 3
20	32 ± 3	—
30	15 ± 3	—
40	8 ± 3	—
106	1 or less	—

Reference: http://www.appie.or.jp/testpowders/details/main3.html

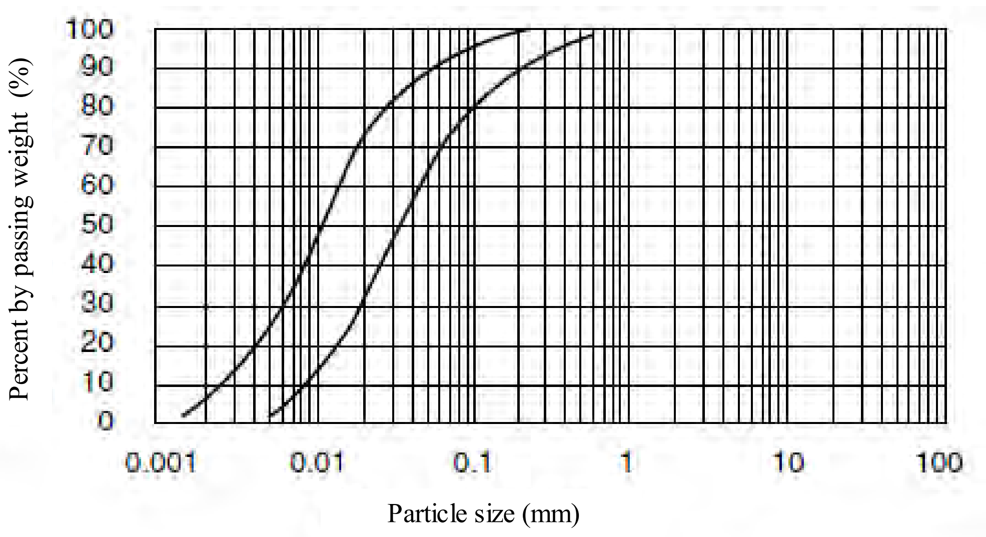


Fig- 3: Particle size distribution of fly-ash

Reference: P-64 of Journal (No. 556: Jan/2003): TENPES

Article 203-1-2. Collection system of cyclone ash

1. The thermal power plant in Vietnam has been mainly dependent on the domestic anthracite and bituminous coal in a last long time, the gas-fired plant has come to be introduced after the development of natural gas fields. However, it is expected to require the importation of foreign coal and liquefied natural gas in order to respond to rising demand for electricity, since there are limits on domestic fuel. In case of coal-fired thermal power plant, it is necessary to expand the construction of large coal-fired plants applying imported foreign coal as main fuel from around 2015. However, the coal-fired thermal power has more environmental problems compared with gas-fire or oil-fire plant in fuel diversification. In particular, the high-efficiency electric precipitator (EP) is required than ever, because the flue gas of coal contains more than 100 times dust compared with the flue gas of oil, in addition, many of overseas coal contains sulfur below 1% (so called low sulfur coal") and high apparent electrical resistivity of the generated fly-ash. It is becoming increasingly necessary to develop a dust collection technology which matches the total flue gas treatment systems including gas processing as well as duct, sulfur oxide (Sox), nitrogen oxide (NOx), etc.

2. Electric precipitator for coal-fired boiler

   The electric precipitator which collects charged dust particles in the flue gas by means of corona discharge and be able to collect dust from high-efficiency with low pressure drop is used extensively in the field of power generation boiler or general industry. In recent year, the importance of the electric precipitator for thermal power plant has been increasingly growing to deliver stable, high performance and reliability at least as the main facility.

2.1 Characteristics of coal-fired dust

The fly-ash which is emitted from coal-fired boiler is composed of the spherical particles of an average of 20~30μm mainly composed of SiO_2,$A1_2O_3$, it is important to confirm its collection performance beforehand when planning of EP, since the dust collection may result in significant differences for coal.

(1) The electrical resistivity of fly-ash and the dust collection performance of EP are highly dependent on the electrical resistivity of collected fly-ash. This difference in electrical resistivity o dust is mainly due to the followings;

1) Exhaust gas temperature
2) Amount of moisture and SO_3 in the flue gas
3) Coal properties and composition of the dust component

Fig-4 shows the relation between current resistivity and gas temperature of fly-ash, and it shows that there is maximum value at around 120~180^{o}C. This is due to differences in how the current flowing in the dust particles at the low temperature and high temperature area, because the current tends to flow surface of the particles due to adsorption of water and SO_3 in the gas as shown in Fig-6. Conversely at high temperature, the current flowing through the interior of the particles becomes dominant. This is influenced by the amount of an alkali metal (such as Na, K) in the dust. The example of the electrical resistivity due to dust and coal ash properties is shown in Fig-5, as seen, it is clear those very large variations in electrical resistivity due to coal.

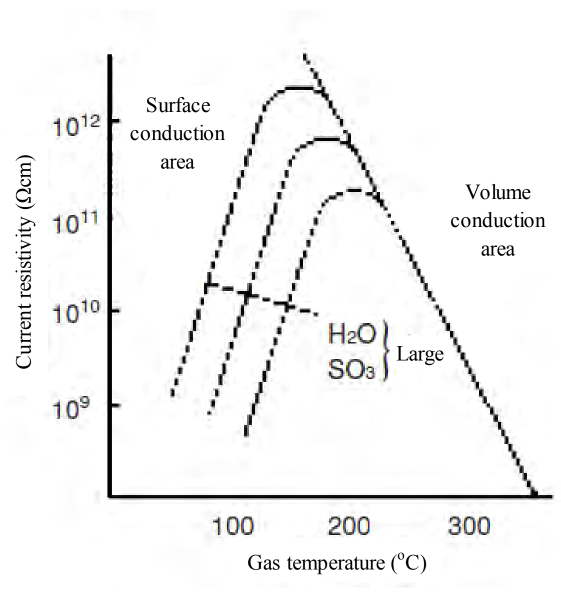


Fig- 4: Relation between current resistivity and gas temperature of fly-ash

Reference: P-81 of Journal (No. 445: Oct. /1993): TENPES

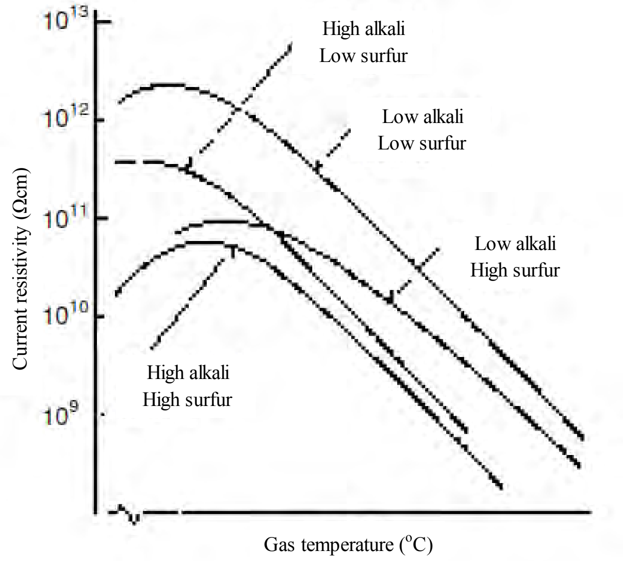


Fig- 5: Electrical resistivity of fly-ash

Reference: P-81 of Journal (No. 445: Oct. /1993): TENPES

(2) Back corona phenomenon

Generally, the precipitator performance is related to the electrical resistivity of the collected dust, charged voltage and current characteristic shown in Fig-6.

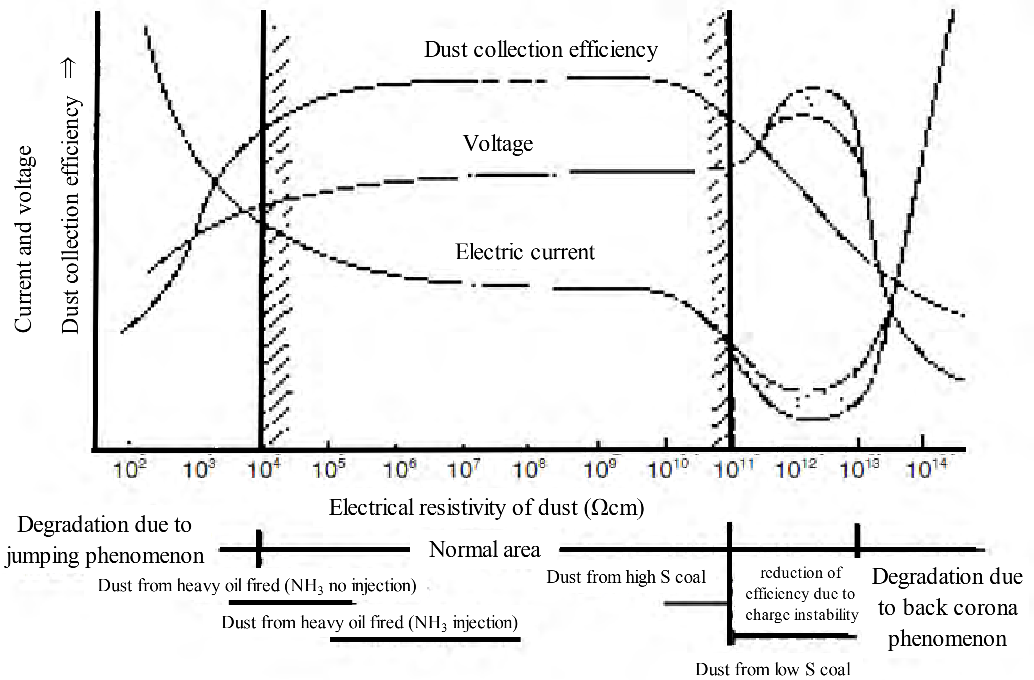
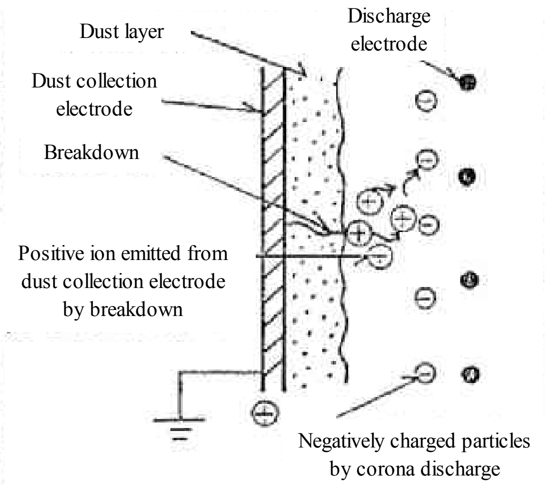


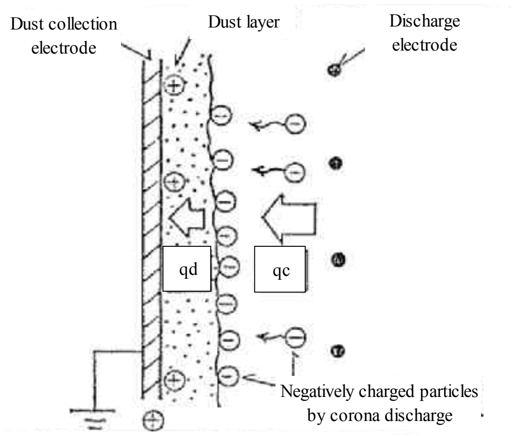
Fig- 6: Electrical resistivity vs. dust collection efficiency of EP

Reference: P-81 of Journal (No. 445: Oct. /1993): TENPES

The precipitator performance is reduced in the area of $10^{11}\Omega cm<\rho d<10^{12}\Omega cm$ due to the reduction of discharge current. This area is known as a high resistance fault and occurs when the collecting electrode surface is covered by the high resistance dust. In addition, the back corona phenomenon occurs in the area of $\rho d \geqq 10^{12}\Omega cm$ and dust collection performance can be significantly reduced due to the rapid current increase and the voltage decrease at the same time. The back corona phenomenon as shown in Fig-8 is the phenomenon that causes a breakdown in the dust layer due to the large voltage drop by the current flowing through the dust layer when the dust layer is extremely high electrical resistivity compared with the normal situation shown in Fig-7. The occurrence of back corona conditions can be shown by the following formula.



<u>Fig- 7: Back corona phenomenon</u>



<u>Fig- 8: Normal situation</u>

Reference: P-82 of Journal (No. 445: Oct. /1993): TENPES

$Id \times \rho d \geqq Eds$ (1)

Where

- Id: Current density in the dust layer
- ρd: Electrical resistivity of dust
- Eds: Breakdown field strength of dust layer

In the event of back corona, a large amount of reverse polarity (positive) ions are discharged from the breakdown point of the dust layer on dust collecting electrode surface toward dust collecting electrode surface (space for dust collection),

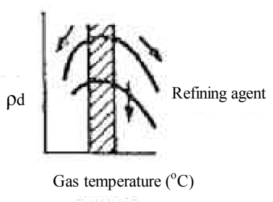
1) Electrical neutralization of charged dust in the precipitation space
2) Distinctive drop of charged voltage

3) Significant reduction of performance of EP due to the abnormal increase of the discharge current (reactive current for the electrical neutralization of charged particles with opposite polarity ion)

2.2 Recent dust collector

The biggest challenge for coal-fired boiler is no exaggeration to say that the overcome of the reverse ionization to maintain and improve precipitation performance against the high resistivity dust. For this reason, various technologies have been developed for the dust precipitation of high resistivity. The improvement technology for high resistivity dust is shown in Table-4.

Table- 4: Improvement technology for high resistivity dust

Measure for high resistivity dust			
1	Eliminate dust layer	Complete removal of dust	Wet-type, moving electrode type
2	Reduction of electrical resistance 	Raising of temperature	Adoption of high temperature EP
		Lowering of temperature	Prefix of GGH
		Injection of refining agent	Injection of SO_3, Na, etc.
		Coal blending, co-firing	Blending with high-S coal, high-S heavy oil or co-firing
3	Control of current flowing through the dust layer	Charge control	Intermittent charging, pulse charging
		Separation of charging part and dust collection part	Spare charging equipment

Reference: P-83 of Journal (No. 445: Oct. /1993): TENPES

(1) Movable electrode type electric precipitator

The dust collection degradation causes due to the back corona phenomenon that the collecting electrode is covered by dust (electrically insulating layer), because dust becomes in sufficient dust off from the dust collecting electrode for strong adhesion with high electrical resistivity of dust. Usually, the moving electrode type EP keeps always clean the dust collecting electrode surface by dropping dust entirely by rotating brush and is intended to prevent degradation and aging of EP, although tapping off of dust has been done by hitting with hammer.

Dust collection is performed while the dust collection electrodes which are separated into strips and connected by a chain link moving in EP in very low speed (about 0.5m/min). Dust trapped in the dust collection electrode is completely brushed off by rotating brush which is placed at the bottom of the dust collection electrode. The moving electrode type EP has been applied to various industries other than power generation such as the glass melting furnace, sludge kiln, cement kiln, sintering machine. The economy is taken into account in its application to the coal boiler, such as applying it in the end part where it is difficult to remove fine dust in the normal hammering method, a good operation situation are shown at a recent large capacity thermal power plant.

(2) New charging type electric precipitator

It is necessary to operate by lowering the applied voltage in order to suppress back corona, because it is necessary reduce current in the normal DC system. In this case, the ability of the dust charging function is decreased and dust collection efficiency is reduced in the conventional EP due to not only the drop of space field strength but also the significant non-uniform distribution of corona current discharged from the discharge electrode.

In contrast, the corona current generated by a pulsed high voltage in the short time from the discharge electrode and is distributed uniformly throughout the discharge electrode. In addition, it is capable to improve precipitation performance by appropriately varying such as the height (voltage), width, and period of charging pulse, because it is possible to obtain significant higher peak voltage than DC charging and improve the charging. Recently, this pulse charging scheme has been researched developed and commercialized worldwide in particular increased interest. The pulse charging is divided into the millisecond pulse, the microsecond pulse by the width of the pulse voltage which is applied to the EP. As millisecond pulse charging system, the intermittent charging system has been used extensively as a primary purpose of energy conservation, and high resistivity dust has been obtained to improve the movement speed of 1.2 times as well as significant energy savings. On the other hand, the micro pulse charging system is spreading worldwide in recent years, although it is new technology, however, there are issues that must be discerned of electrical resistivity of dust, since it is necessary high-speed switching device, power charging and coupling capacitor, pulse generator in addition to usual high voltage power supply facility and they are expensive. However, the pulse charging system not only contributes to the improvement for precipitation performance of high resistivity dust but also has already been applied to actual plants, which is attracting attention from the viewpoint of energy conservation.

(3) High temperature electric precipitator

The high temperature EP has been employed for coal-fired power in USA in the 1970s. The problem of dust collecting performance degradation occurred by the back corona phenomenon due to the high resistivity dust in the EP, as the result of change of the emission regulation of dust and Sox has been enhanced and high-sulfur eastern coal fuel (east of the Mississippi River) were converted to low-sulfur western coal. In response, a number of high temperature EPs are employed which are able to collect dust in the high temperature area (320～380 ^{o}C) where the electrical resistivity decrease, therefore, the high temperature EP can be specifically collected fly-ash which could not be collected in a conventional low temperature EP.

However, for some coal with low Na_2O in the dust does not degrade the electrical resistivity which can be applied EP even at high temperature and occurs the degradation phenomenon of dust collection performance, so sufficient examination is required when applying. In addition, it is necessary to consider careful selection of material, thermal distortion and thermal expansion of structure to withstand high temperature as compared low temperature EP prevention of energy loss along with an increase in the amount of process gas, because high temperature is operated in the area 320～380 ^{o}C.

(4) Wet type electric precipitator

The wet type EP is the best high-performance compact model, because there is no impact at all from the electrical resistivity and no scattering and is capable to keep gas faster velocity in the EP. However, there are issues that it uses plenty of water, it is necessary to treat slurry of collected dust, it is difficult to apply to high dust concentration and it is required to drop gas temperature to saturation temperature. This has already been commercialized as part of the gas treatment system, because it is the best model to collect dust and mist in the outlet of wet type de-Sox in the gas treatment system of boiler.

The wet type EP has been considered a variety of structures for power generation, although it has been employed in long time as industrial EP and fewer large ones. Fig-9 shows the construction of EP. The flat dust collection electrode is adopted in order to process the massive gas, creating a liquid film on the electrode surface by spray nozzle from its top and flowing down always with liquid. The discharge electrode with a tip of the needle-like shape is adopted in order to prevent the mist from the inhibition of desulfurization by corona current and is measured stability of the dust collector performance.

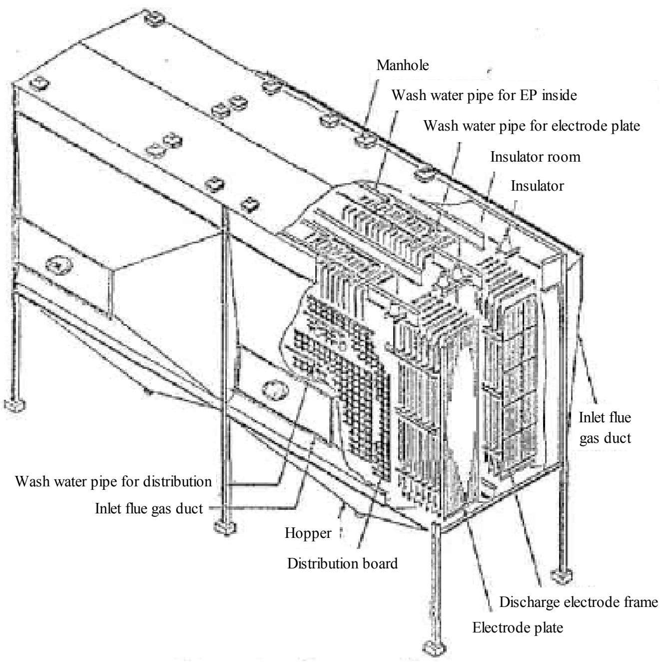


Fig- 9: Wet type EP

Reference: P-85 of Journal (No. 445: Oct. /1993): TENPES

3. Bag filter

Bag filter has been widely used in general industry such as iron manufacturing or cement manufacturing and the bagfilter for coal-fired thermal power plant has been promoted primarily for practical use in USA similarly to the EP. The bagfilter has been investigated because the EP is not necessarily committed by use of low sulfur coal and the electrical resistivity of dust (type of coal), and the first BF for 175MW class coal-fired thermal power plant was installed in 1973 in the USA, currently being operated by BF of about 100 units. The features of bag filter are its high performance and no effect of coal type compared with EP. On the other hand, there are issues such as large draft loss, large space for installation and the life of filter cloth.

The bagfilter is already commercialized for industrial boiler (pulverized and fluidized boiler) in Japan; however, it has not been applied yet because of the difference in required performance of dust collection as the total processing system, more economical and maintenance issues. However, it is considering the application of ceramic filters to clean up the upstream gas turbine systems for the coal gasification combined cycle and the pressurized bed combustion power generation, etc. as new generation technology considering the future energy situation.

4. Cyclone

The multi-cyclone is the dust collector which separates dusts contained in air by a strong swirling flow as shown in Fig-10. The untreated gas is accelerated when passing through the guide vanes and become a strong downward swirling flow in cyclones, inverted and rise at the conical part. The dust reaches the outer cylinder by a strong centrifugal force, falls together with swirling flow and is discharged from the hopper to the conical opening at the bottom. On the other hand, reversal swirl flow raise at the cyclone center and the clean gas is exhausted through the orifice exhaust pipe.

The dust removal of fluidized bed boiler is performed between boiler and rear heat transfer area by cyclone as shown in Fig-11, 12, 13, since the fine ash scatter into the wake. The collected ash is extracted with coaster ash from bottom and will be cooled, classified and processed in the ash treatment facility.

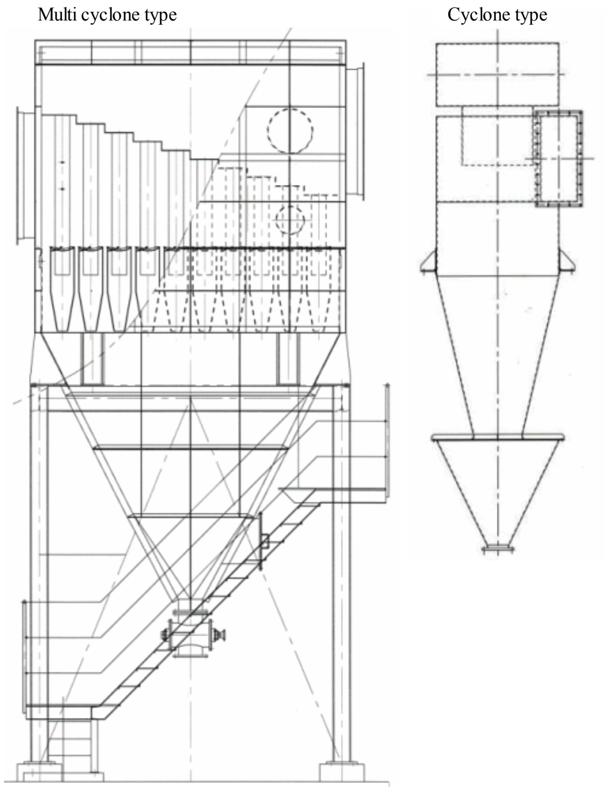


Fig- 10: Cyclone and multi-cyclone

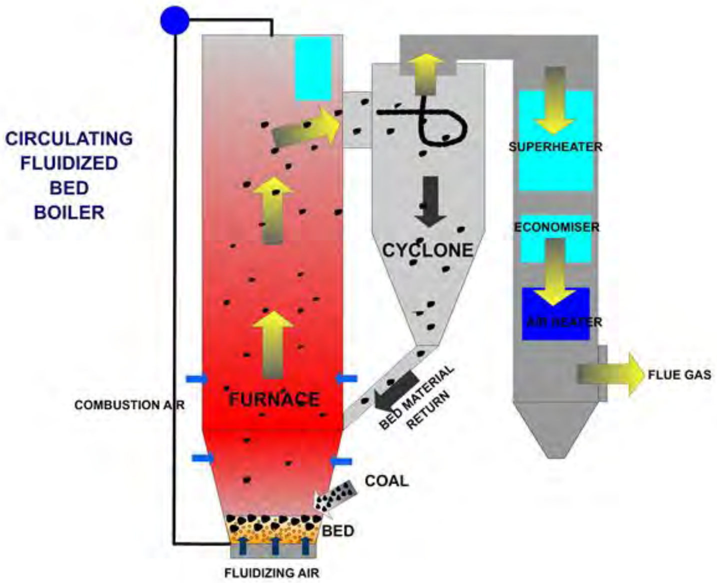


Fig- 11: Circulating fluidized bed boiler (CFB)

http://www.brighthub.com/engineering/mechanical/articles/26547/image/49099/

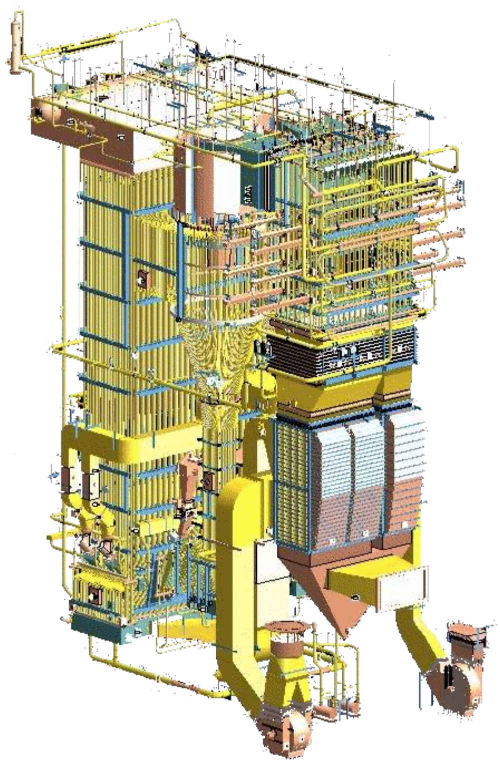


Fig- 12: Fluidized bed boiler (Foster Wheeler)

http://www.idsincorp.com/b-misc1.html

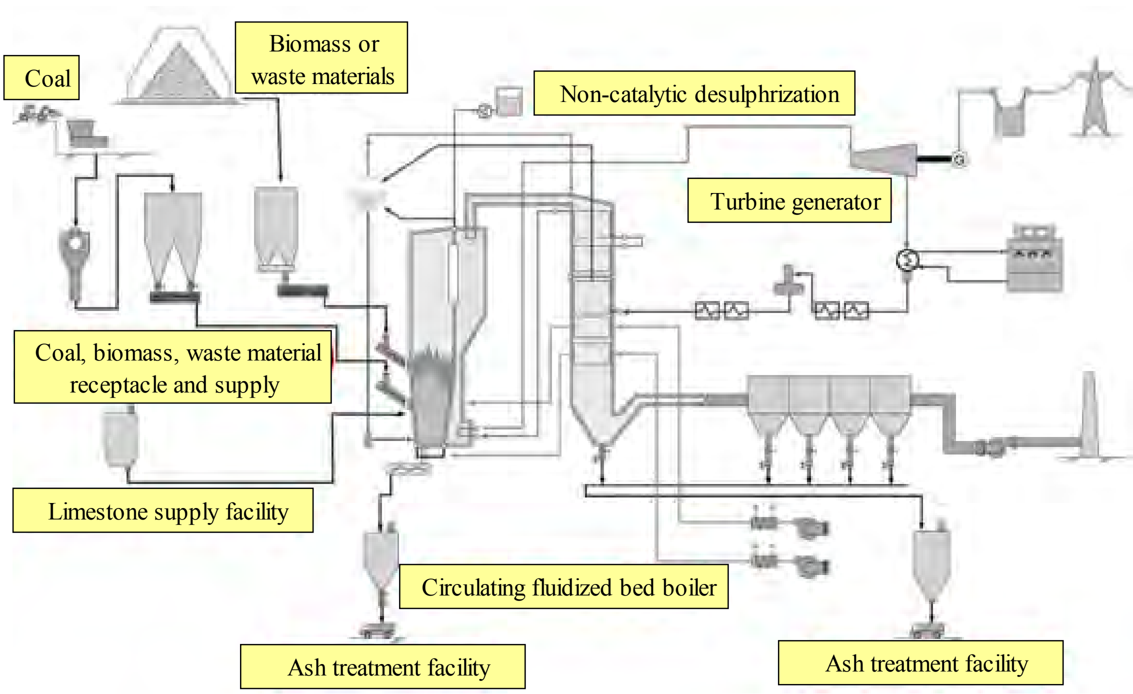


Fig- 13: CFB boiler and ash treatment system (SHI)

http://www.shi.co.jp/english/products/enepla.htm

Article 203-1-3. Transportation system of cyclone ash

1. The Dense Ash Conveying System as shown in Fig-14, 15, 17, Photo-5, 6, 7, 8 is pneumatic pressure systems conveying dense ash at a low velocity. This is suitable for conveying a large volume and the corrosion of ash pipes is reduced due to its low velocity conveying. This system consumes less energy due to its smaller amount of conveying air, for the bore of an ash conveying pipe can be made smaller.

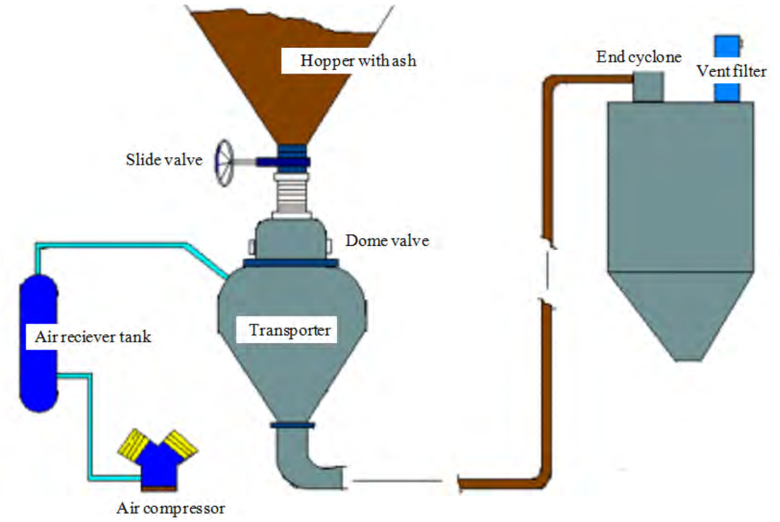


Fig- 14: Principle of air conveying system

http://anuelevators.in/

Photo- 5: Dence phase pneumatic transporter

http://www.kockumsbulk.com.au/powder_handling_products/20-dense_phase_pneumatic_conveyor

Photo- 6: Dence phase pneumatic transporter

http://www.kockumsbulk.com.au/powder_handling_products/20-dense_phase_pneumatic_conveyor

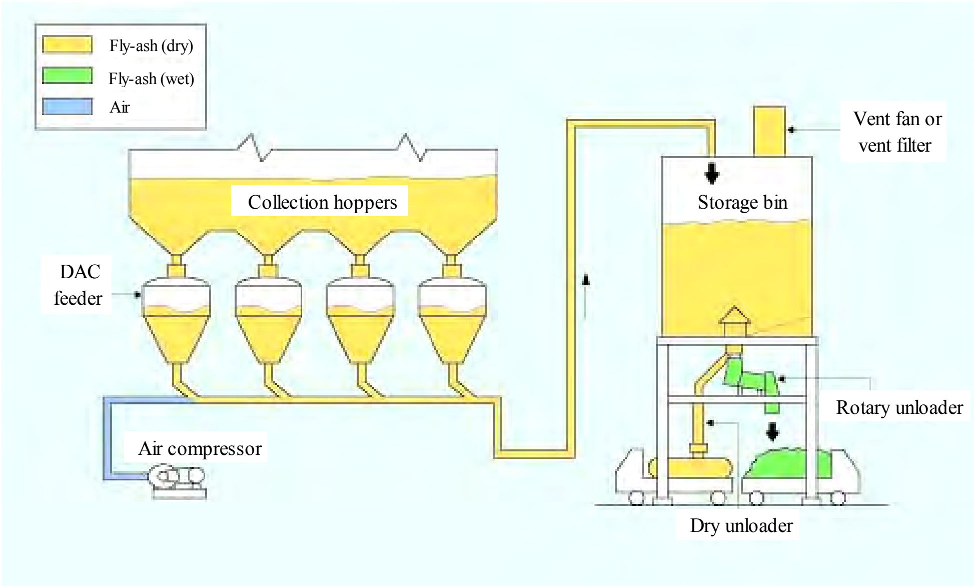


Fig- 15: Dense ash conveying system (KHI)

http://www.khi.co.jp/english/kplant/business/energy/surround/images/density_il001.jpg

2. The pneumatic conveying system conveys fly ash in an air stream at positive pressures and is suitable for a large capacity conveying for a long distance. This system is also suitable when fly ash is distributed to multiple storage places. Fly ash in each hopper goes through a pneumatic conveyor and is fed into a pressurized stream produced by a pneumatic blower and blown into a fly ash silo directly for storage. An exhaust bag filter is installed on the fly ash silo to purity air for the pneumatic conveying system. After storage in the silo, fly ash is conveyed like the vacuum conveying system as shown in Fig-16.

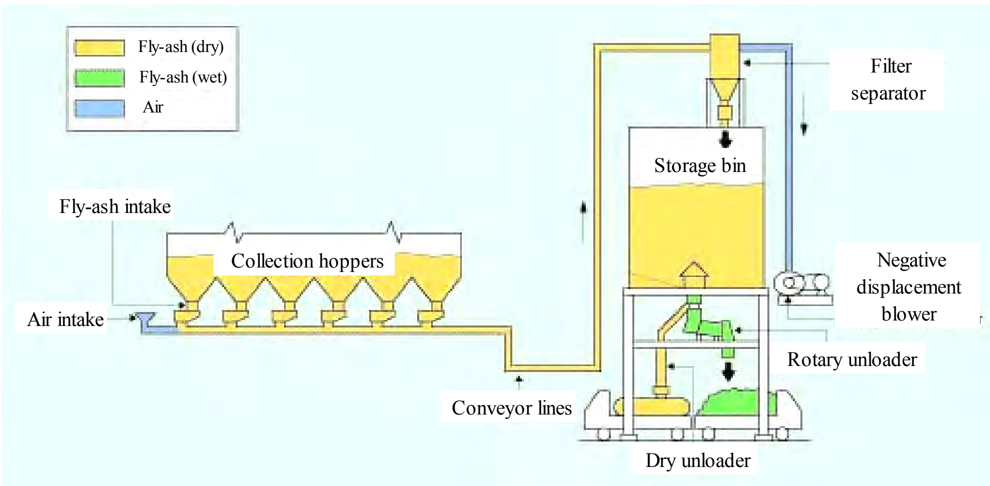


Fig- 16: Vacuum conveying system (KHI)

http://www.khi.co.jp/english/kplant/business/energy/surround/images/transport_il001.jpg

3. The Vacuum Conveying System as shown in Fig-16, 18, Photo-9, 10 conveys fly ash in an air stream at negative pressures and is suitable for a comparatively short conveying distance. This system is extensively used for its simplicity and economic efficiency. Fly ash in each hopper is conveyed through a pipe by a vacuum blower, caught by a filter separator on the top of a silo and deposits in a fly ash silo. The ash stored in the silo is moistened by a dustless unloaded and conveyed to an ash disposal site by truck or conveyor. The ash can also be conveyed as dry for efficient utilization.

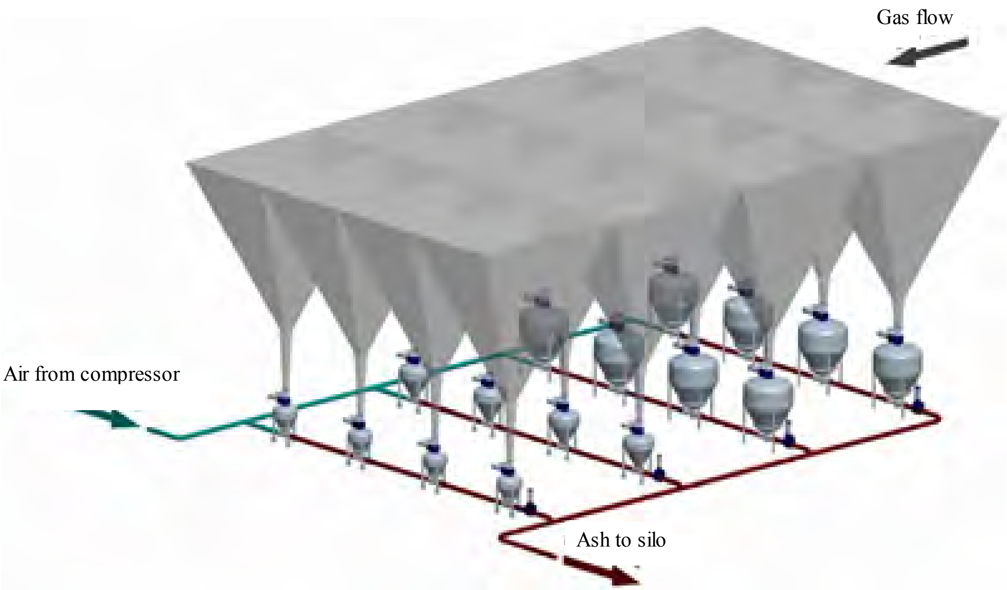


Fig- 17: Dense phase pneumatic transportation system

http://www.ewb.hu/flyash.html

Photo- 7: Transport vessel

http://www.ewb.hu/flyash.html

Photo- 8: Transport vessel

http://www.ewb.hu/flyash.html

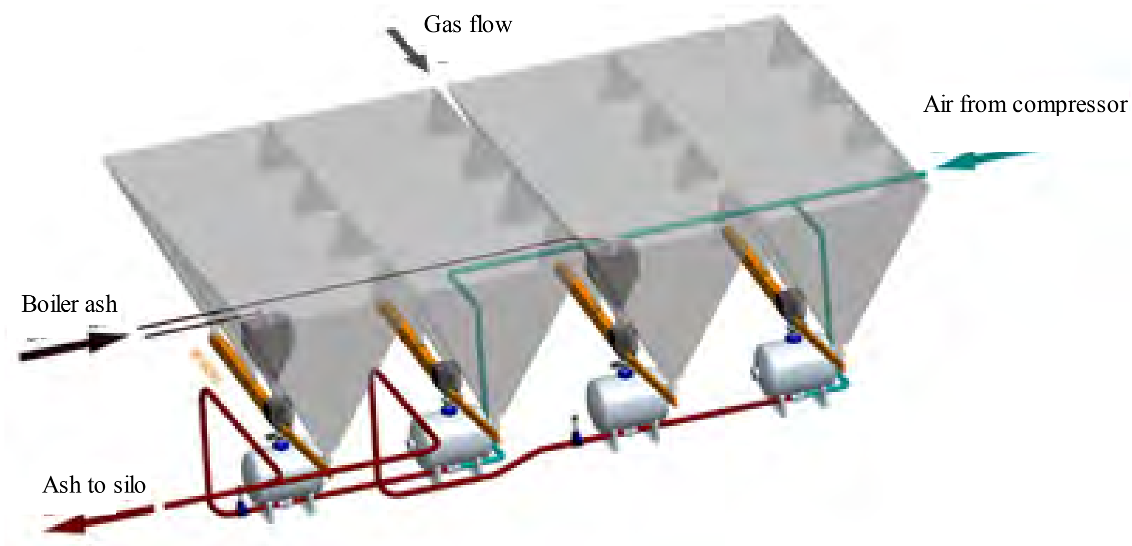


Fig- 18: Combination of airslides and pressure vessel system

http://www.ewb.hu/flyash.html

Photo- 9: Fly-ash transporter

http://www.khi.co.jp/corp/ke/product/ash2.jpg

Photo- 10: Air slide conveyor

http://www.flsmidth.com/en-US/Products/Product+Index/All+Products/Pneumatic+Transport/Fly+Ash+Handling/Network+Gathering+Systems

Article 203-1-4. Design requirement

1. Increased use of treated ash

   Mainstream of unit capacity becomes 1,000MW class and power plant capacity has been increased to 2,000MW. Therefore, the amount of ash handling has increased exponentially and the capacity of treatment facility accordingly.

2. Distributed arrangement of ash handling facility

   The ash storage facilities have been forced to be located far away from the boiler EP with the increase in scale of power plants. In addition, the shipping facilities have been located away from ash storage facility. Along with these, transportation of ash has been growing long distance to the conventional.

3. Change in ash properties

   The use of overseas coal becomes a mainstream with a wide range of properties, and moreover, its range of coal types expands. This makes varying a wide range of properties and the amount of ash, it has been required to consider them carefully in order to plan an economic and rational ash treatment facility.

4. Cooperation with other planned facilities

   Recently, shipping facility is provided in many cases. In this case, gypsum belt conveyor, gypsum shipping facility, and coal unloader have been required a reasonable cooperative arrangement with other shipping facility , wet ash belt conveyor, dry ash belt conveyor, wet ash shipping facility, dry ash shipping facility.

5. Environmental measure

   There is still some dirty working such as a part of shipment of ash, though there is no rarely dirty transportation working in the pipe transportation. The further improvements of working environment in line with the recent request must forward.

6. Correspondence to new coal utilization technologies

   The ash treatment facility corresponding to new technology such as pressurized fluidized bed boiler or CWM fuel boiler and coal gasification has become necessary.

Article 204. Cinder ash collection and transportation facility

Article 204-1-1. Nature of cinder ash

1. The cinder ash which is not fallen into the furnace bottom as a clinker ash, which could not jump to the dust collecting facility from flue gas such as EP, bag filter, cyclone, which is grown in heat recovery area or air heater are the ash recovered in the economizer hopper and the air preheater hopper. The properties are close to the fly-ash.

Article 204-1-2. Collection system of cinder ash

1. The cinder ash is collected by falling into the hopper by its weight without using special collection equipment.

Article 204-1-3. Transportation system of cinder ash

1. The cinder ash which falls into the economizer hopper and the air preheater hopper is transported to the classifier as well as transportation by air transportation system from hopper of EP, bagfilter and cyclone, etc.

Article 204-1-4. Design requirement

1. There are two systems, one is to mix cinder ash with fly-ash and the other is to avoid mixing of each other. It is necessary to select either system depending on the component of ash corresponding to the applied fuel coal. It is necessary to classify fly-ash in the cinder ash efficiently for effective use of cinder ash.

Article 205. Clinker ash collection and transportation facility

Coal ash falls into bottom of the furnace as the bottom ash (clinker ash) in the coal-fired boiler. The facility to unload furnace bottom ash from boiler is the bottom ash treatment facility.

Article 205-1-1. Nature of clinker ash

1. Distribution and properties of clinker ash

Coal ash is generated as residue after combustion in the coal-fired boilers because coal contains about 5~30% ash. The coal ash is classified into bottom ash (clinker ash) which is collected at the bottom of furnace and scattered ash (fly-ash) which is scattered from furnace and collected in the hopper of dust collector. The proportion of clinker ash of coal ash generated is about 10~20%, fly-ash of coal ash is 80~90%, although the occurrence percentage of each other varies depending on boiler type.

The clinker ash is melted various inorganic components of coal ash during combustion of pulverized coal in high temperature and is formed and solidified such as adhering to boiler heat transfer surfaces. They grow, peal naturally and fall down to the bottom of furnace by means of operation of sootblower. Most of the main component of the clinker ash is silicon dioxide and aluminum oxide, and shape or form has become a massive sand grains.

2. Chemical property

The clinker ash was a massive coal ash which was falling into the bottom tank of boiler with the red-hot state and was adjusted by crushing grain by crusher. It is chemically stable for red-hot state, since washed with water quenching. The main component of the cinder ash is almost same "silica" and "alumina" as fly-ash and the component of clinker ash is shown in Table-5, however, it is used taking advantage since there are lots of small holes in the surface of clinker ash and has the advantage of water retention, drainage and breathability. It is used in the field taking advantage of the characteristics.

Table- 5: Chemical composition of ash

	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO
Fly-ash	40.1 ~ 74.4	15.7 ~ 35.2	1.4 ~ 17.5	0.2 ~ 7.4	0.3 ~ 10.1
Clinker ash	51.6 ~ 64.0	17.3 ~ 26.9	4.2 ~10.9	1.0 ~ 2.6	2.3 ~ 8.8

Remarks: The variation depends on the type of coal.

Reference: P-72 of Journal (No.609: June/2007): TENPES

3. Physical property

The clinker ash particles are almost composed of fine gravel and coarse sand, which is close to the size distribution of sand as shown in Photo-12. When looking at the surface of the clinker ash by electron microscope, it can be seen many vacant small pore with diameter of about 0.2~20μm as shown in Photo-11. These pores of clinker ash will be the size of $0.148cm^3/g$. 1g of clinker as has a surface area of approximately 4.5 m^2, it must have approximately 10,000 times the surface area of particles of same diameter without the pores.

The clinker ash will be used for roadbed underlying for the road and golf course material, intermediate materials for ground, backfill material for wharf, lightweight fill, since it has the pore structure, unit weight is lighter than sand, excellent drainage and good breathability and has excellent water retention and fertilizer retention. The relation between the percentage passing per weight and particle size is shown in Fig-19.

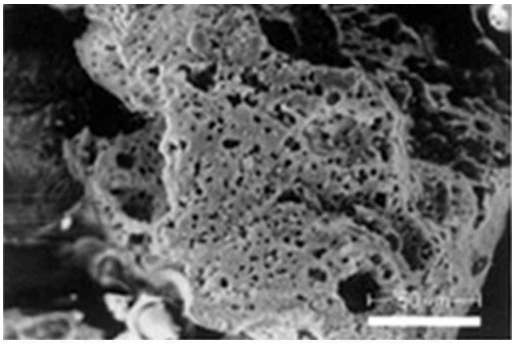


Photo- 11: Micrograph of clinker ash(X300)

http://www.japan-flyash.com/cchemiphysi.html

Photo- 12: Real photo of clinker ash

http://www.japan-flyash.com/cchemiphysi.html

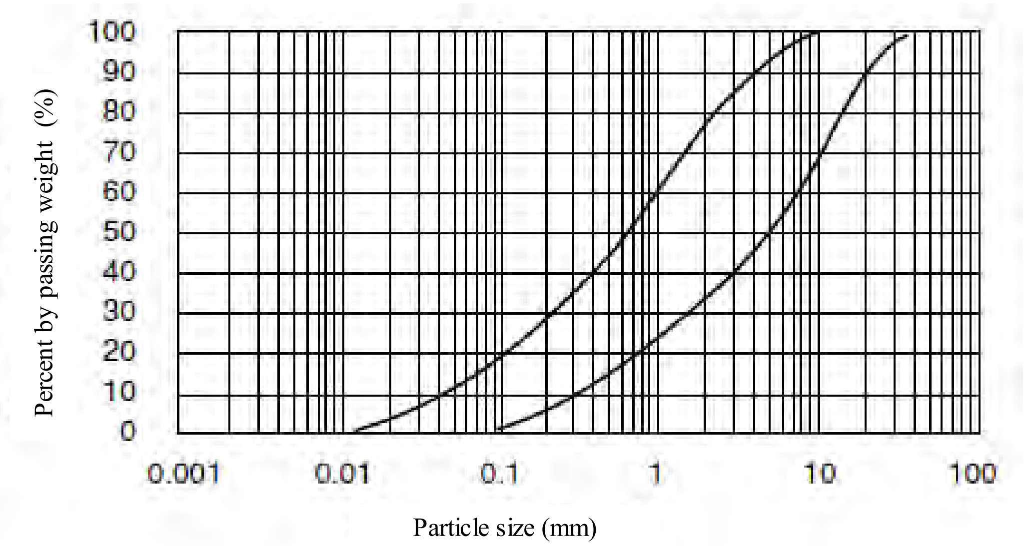


Fig- 19: Particle size distribution of clinker ash

Reference: P-64 of Journal (No. 556: Jan/2003): TENPES

Article 205-1-2. Collection system of clinker ash

1. Clinker ash is collected without any special equipment and collected by gravity to the hopper of the economizer or air preheater. Collected ash is transported by the same system as fly-ash.

Article 205-1-3. Treatment facility for clinker ash

1. Bottom ash treatment facility

   The processing method of furnace bottom ash (clinker ash) is classified as shown in Fig-20 and the treatment system is selected by considering the capacity of boiler, operation method, space for installation. The continuous, wet-type, mechanical discharge type and water seal type chain conveyor is general for large utility boiler in German. The intermittent ash flow pipe type adopting water jet pump and slurry pump in Europe except Japan, USA and German. However, continuous, wet-type, mechanical discharge type and water seal type chain conveyor has become common practice in Europe recently. The continuous, wet-type, mechanical discharge type is mainly adopted for the capacity of industry boiler in Japan.

   The wet process cooling down ash in a hopper and trough, etc. filled water under the furnace and transport was the mainstream of conventional treatment. Recently, the dry type conveyor cooling ash by air during transportation has been developed and the plant which applying this method has been increased for Japanese or international large capacity boilers for industry and power generation in addition to the wet process. Furthermore, the transformation from wet process to dry process is under way in foreign plants.

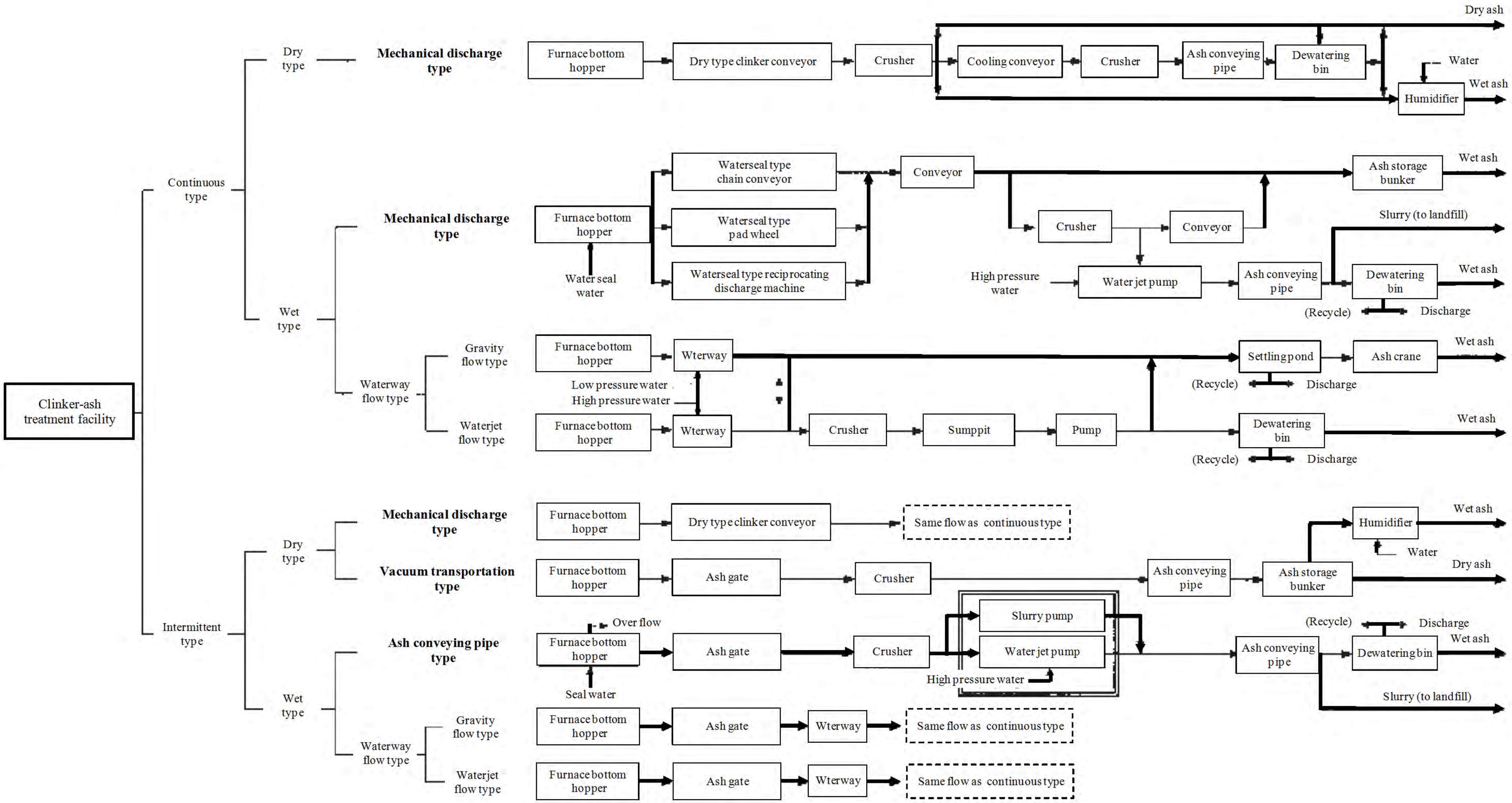


Fig- 20: Classification of the treatment method of clinker ash

Reference: P-67 of Journal (No.587: Aug. /2005): TENPES

2. Dry type clinker treatment process

Fig-21 shows an example of a basic flow of dry clinker treatment system and Fig-22 shows an arrangement example. The core is the dry clinker conveyor handling system as shown in Fig-23, a heat resistant conveyor with mesh belt structure. The generated clinker ash drops onto dry type clinker conveyor passing through a transition hopper which interior is covered by refractory material. Clinker ash fallen down onto conveyor is transported to crusher while being cooled by air on the heat resistant belt and crushed. Then, clinker ash may be capable to transport by air transportation, conveyor in wet state, truck transportation by means of further cooling and transporting by cooling conveyor and secondary crushing, if required. In addition, the operation of dry clinker conveyor can be adapted to handle intermittent and continuous process as well

The cooling air is inhaled from outside through conveyor trough, and the cooling air has been adjusted to about 1% of the combustion air of boiler considering the impact for boiler. Also, it is possible to provide bottom valves as can be easily shooting of trouble of downstream equipments.

This process has the advantage compared with other process such as the followings.

(1) Configuration of equipment is simplified, because no need cooling water and circulating water
(2) Heat recovery from combustion of unburned fuel in the clinker on the heat resistant conveyor
(3) Reduction of total transportation power, since limited transportation only clinker different with wet type
(4) Availability a wide range of effective treatment mixed with fly-ash, since it can be discharged clinker ash with less unburned fuel and in dry state

The dry type system has been used to increase in the industrial boilers, the large capacity power generation boilers from the viewpoint of effective utilization of coal ash.

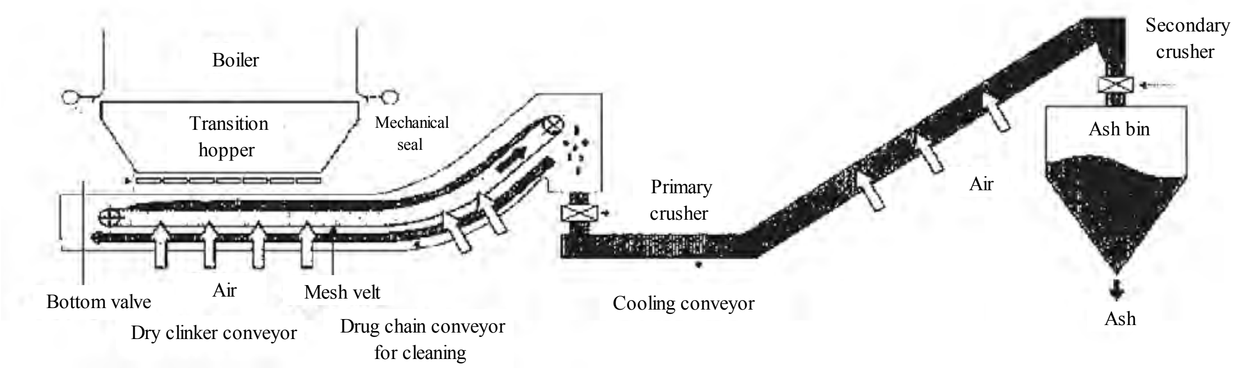


Fig- 21: Basic flow of dry type clinker ash treatment system

Reference: P-67 of Journal (No.587: Aug. /2005): TENPES

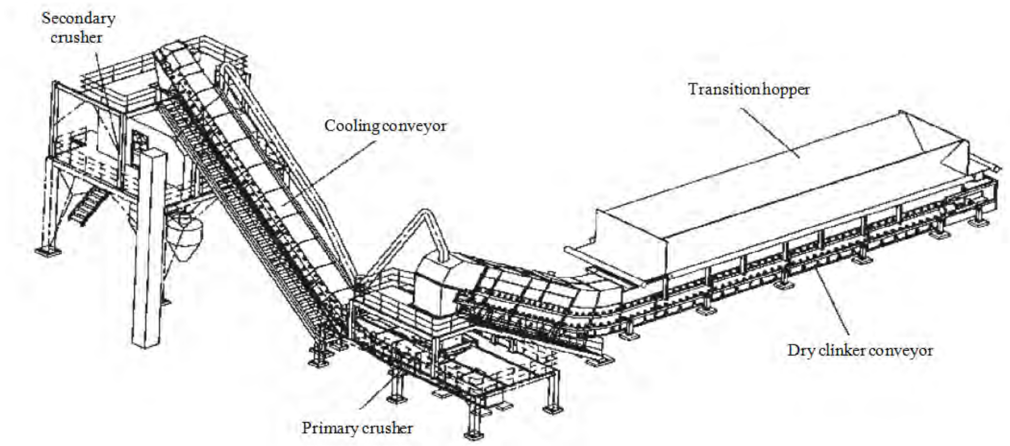


Fig- 22: Arrangement of flow of dry type clinker ash treatment system

Reference: P-68 of Journal (No.587: Aug. /2005): TENPES

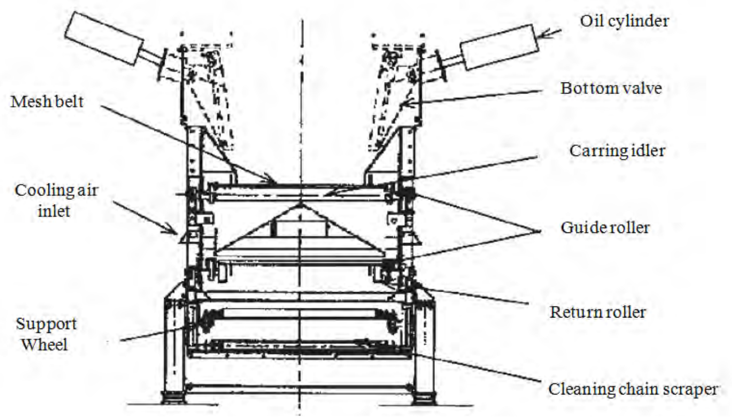


Fig- 23: Cross section of dry clinker conveyor

Reference: P-68 of Journal (No.587: Aug. /2005): TENPES

3. Water seal type chain conveyor treatment process

Fig-24 shows basic flow of the water seal chain conveyor treatment process. The key of the process is the water seal chain conveyor as shown in Photo-13, Fig-25, 26 and 27, which is the scraper conveyor having a vertically divided trough. Water is filled on top of the conveyor trough and the furnace has been sealed and clinker ash is cooled. Clinker ash fall into the upper trough conveyor through the transition hopper, is cooled down and is transported to the outlet continuously by the scraper. Clinker ash is de-watered at the slope part and is transported to the ash storage facility by conveyor, etc. after crushing by crusher.

Cooling water reserved in the trough at the top of the water seal chain conveyor is the recirculation cycle which comes back via circulating water pump and cooler. In addition, it may be installed alone as a clinker ash facility or it may be incorporated into the overall water cycle system of power plant. It is necessary to monitor such as the concentration of fine ash or the pH level of cooling water which is carry over from the water seal chain conveyor, since the management of water quality is required in this cooling water system.

This process has the advantage compared with other process such as the followings.

(1) Lower the height of the boiler building, because there is no hopper below furnace
(2) Can be transported and processed mill pyrite discharged from coal mill simultaneously with the clinker ash pouring into water seal chain conveyor

This treatment process has been adopted in many industrial power plants in Japan so far.

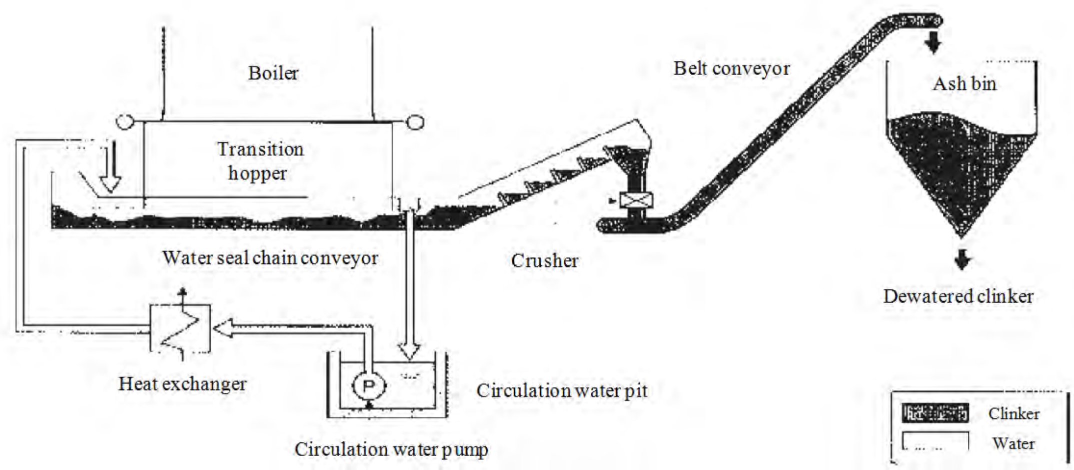


Fig- 24: Basic flow of water seal chain conveyor treatment method

Reference: P-69 of Journal (No.587: Aug. /2005): TENPES

Photo- 13: Water seal chain conveyor

http://www.processbarron.com/ash-handling-equipment/bottom-ash-conveyors

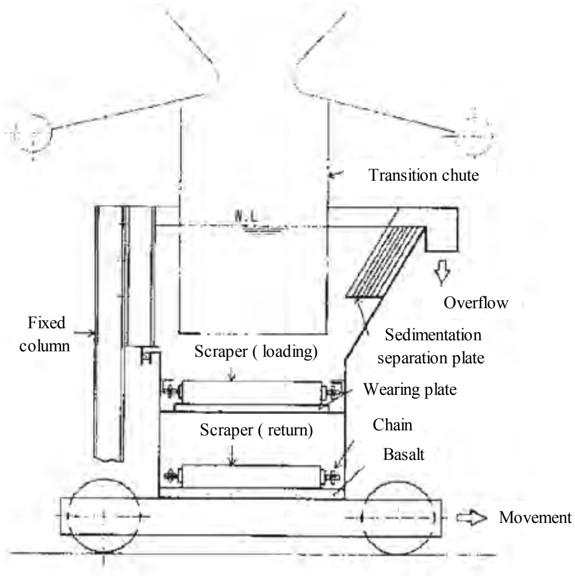
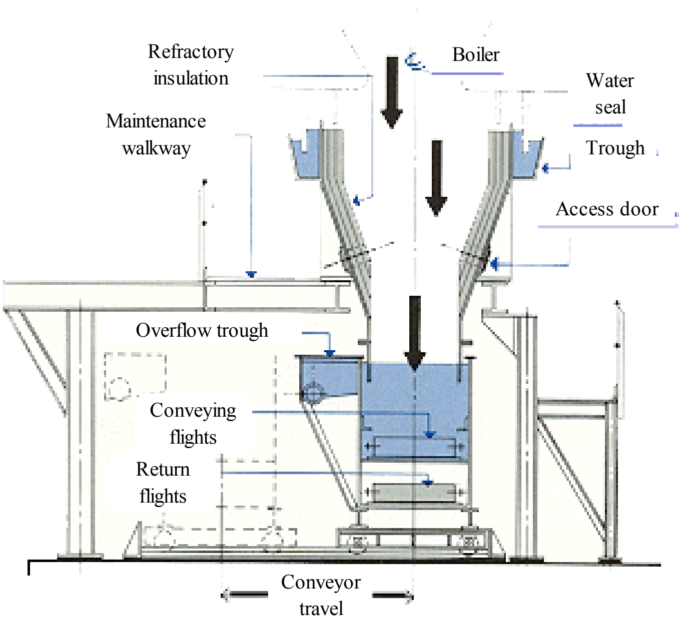


Fig- 25: Cross section of water seal chain conveyor

Reference: P-69 of Journal (No.587: Aug. /2005): TENPES

Bottom ash continually falls from the furnace throat, through the insulated bottom ash chute, and into the water-filled submerged conveyor trough. Cooled ash is conveyed along the bottom of this trough by conveyor flights attached at both ends to continuous loops of conveyor chain. As the ash-laden flights leave the water-filled trough and travel up the dry incline, the ash drains and dewaters itself. The dewatered ash is discharged to a takeaway conveyor or storage area. The conveyor flights return in a lower compartment which is open for maintenance.



Section A-A

Fig- 26: Submerged chain conveyor systems

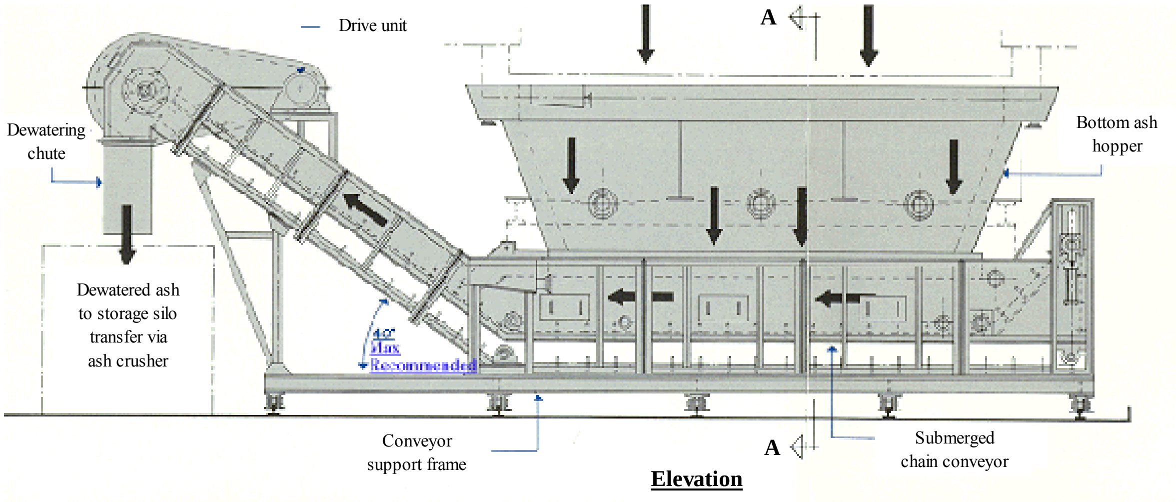


Fig- 27: Submerged chain conveyor systems

http://www.google.co.jp/imgres?imgurl=http://www.ashtechcorp.com/SubmergedChainConveyorSystems_files/submerg2.gif&imgrefurl=http://www.ashtechcorp.com/SubmergedChainConveyorSystems.htm&usg=__tc8VYK69JMTdWcuODfxcuMVKOUY=&h=306&w=316&sz=25&hl=ja&start=74&zoom=1&tbnid=6VWMfyw-HclV3M:&tbnh=113&tbnw=117&ei=1LSnTpjNIoTnmAWWovWkDw&prev=/search%3Fq%3Dash%2Bloading%2Bchute%26start%3D63%26hl%3Dja%26sa%3DN%26gbv%3D2%26tbm%3Disch&itbs=1

4. Piping transportation system（water jet-pump system, slurry transportation system）

Fig-28 shows the basic flow of the piping transportation system. Clinker ash falls into clinker hopper which is placed below the furnace and filled with water and is deposited as shown in Fig-29. Clinker ash will be discharged to dewatering tank or the landfill with retention water in the hopper in every 8 hours by water jet pump (JPP: jet pulsion pump) or slurry pump. Clinker ash which was put into settling tank are separated from water, and transported by truck after dewatering. The water separated by dewatering tank is recycled as system water after removal of carried over sludge from settling pond. In addition, if the ash slurry is discharged directly to the landfill, seawater may be used as ash treatment water in case of the coastal power plant. The ceramic lined pipe as shown in Photo-14 is used for long-term use; otherwise the cheap non-lined pipe is used in the viewpoint of economy as shown in Photo-14, 15.

This process has the advantage compared with other process such as the followings

(1) Most maintenance is possible without shutting down the boiler, since it is intermittent process

(2) No constraint of the transportation path, since by piping transportation

This treatment process has been adopted in many large scale power plants so far.

Photo- 14: Ceramic liner pipe

http://www.engineerlive.com/Power-Engineer/Focus_on_Coal/Ceramic_liner_is_tougher_than_coal_clinker/23806

Photo- 15: Coal ash slurry pipe

http://www.indiamart.com/company/2227063/other-products.html

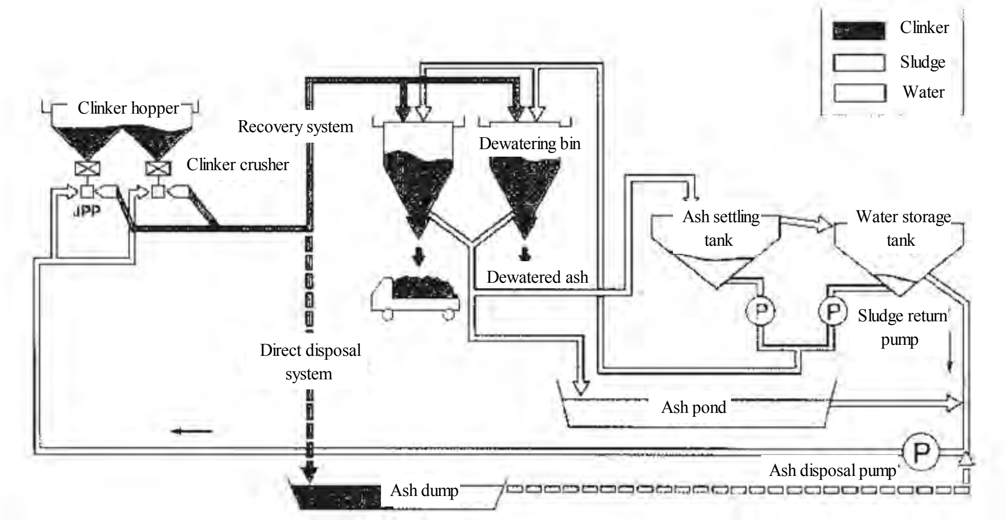


Fig- 28: Basic flow of water and ash

Reference: P-70 of Journal (No.587: Aug. /2005): TENPES

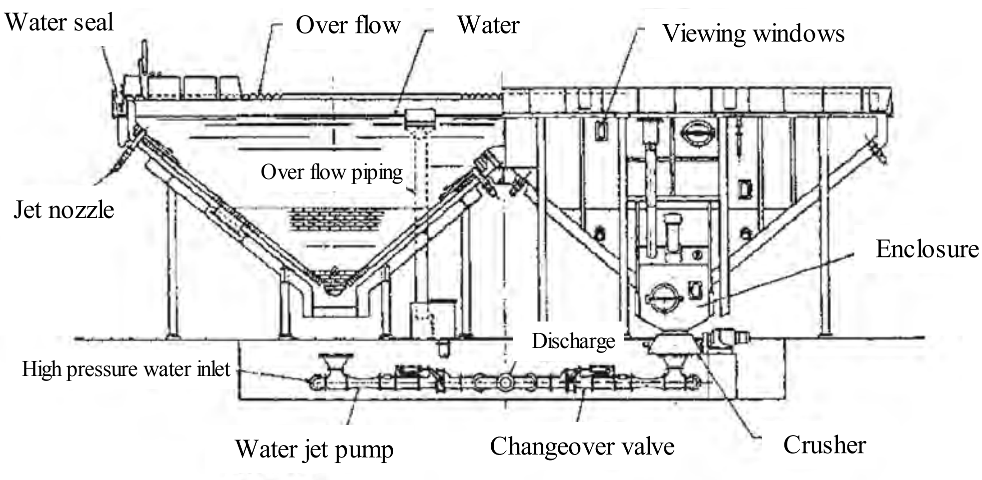


Fig- 29: Clinker hopper (W type)

Reference: P-70 of Journal (No.587: Aug. /2005): TENPES

Article 205-1-4. Design requirement

1. The clinker hopper/ jet palsion pump hydraulic transportation has been widely adopted in Japan and North America for the processing of clinker ash. It has been recognized a big advantage that jet palsion pump is compact and lightweight, easy maintenance, no rotation and sliding parts and less constraint of transportation routes for the transportation pipe.
2. The water seal chain conveyor has been adopted in Europe with a focus to West Germany. This system has a great advantage of less water supplement and power consumption; the adoption will be increased further in Japan, if the conditions such as equipment arrangement below boiler furnace, straight line arrangement of conveyors from boiler house to the main storage area in the premises are met.
3. The clinker hopper/ slurry pump system has been adopted in a part of USA. It is expected to be adopted depending on the further conditions of the power plant, since it has the advantage to apply large capacity pump with low power consumption, though there is a disadvantage theta requires periodic replacement of the pump impeller.

Article 206. General provision of ash collection and storage facility

Article 206-1. Gypsum

1. Gypsum

Desulfurization gypsum is recovered from power plant, metal refining, chemical and other plants using a fuel containing sulfur by means of recovering SO_2 or SO_3 in the flue gas (lime stone method). In thermal power plants in Japan, approximately half are adopted desulfurization system which produces gypsum as byproduct (wet limestone-gypsum method).

The generation of desulfurization gypsum from thermal power plants is shown in Table-6; the power plants accounting for a large weight in the gypsum market.

Table- 6: Processing method

Total amount	Processing method			
	Raw material for cement	Gypsum board	Material for soil improvement	Final disposal
1,467,412	869,011(59.2%)	593,205(40.4%)	14(0%)	5,183(0.4%)

(Unit: ton)

Reference: P-75 of Journal (No.556: Jan. /2003): TENPES

Article 206-2. Selection of ash treatment method

1. Characteristics of desulfurization gypsum

The physical properties of the test results of gypsum byproduct from thermal power plants are shown in Table-7, both are high quality, no problem even on other uses of cement boards, 99.6% and more have measured the effective use as shown in Table-8. The quality that is required to be used as desulfurization gypsum for cement or plaster board is shown in Table-9.

Table- 7: Typical composition of gypsum

Test items		Measurement	
		Reading	Average
Specific gravity	—	2.49 ~ 2.56	2.53
Fines	cm^2/g	2.020 ~ 2.470	2.250
Compressive strength	kg/cm^2	40 ~ 96	75
Moisture adhering	%	0.7 ~12.3	6.4
Combined water	%	18.0 ~ 20.9	20.1
Calcium oxide	%	31.1 ~ 32.9	32.4
Sulfate	%	43.1 ~ 46.2	45.5
pH	—	4.8 ~ 9.3	7.2
Aluminum oxide	%	0.01 ~ 1.68	< 0.17
Silicon dioxide	%	0.02 ~ 5.24	< 0.50
Ferric oxide	%	0.01 ~ 0.44	0.10
Sulfide sulfur	%	0.002 ~ 0.78	< 0.009
Chlorine	%	0.01 ~ 0.08	< 0.02
Free acid	%	0.005 ~ 0.065	< 0.011

Reference: P-75 of Journal (No.556: Jan. /2003: TENPES

Table- 8: Quality standard for cement

		Quality standard (limit values)	Quality standard (effort target values)
Moisture adhering	%	< 10	< 8
Sulfate(SO_3)	%	> 44	> 45
Free carbon	—	White color more than equal to No.5 color swatch	White color more than equal to No.3 color swatch
Calcium carbonate ($CaCO_3$)	%	—	< 1
Calcium sulfite ($CaSO_3 \cdot 1/2H_2O$)	%	—	Minimizing
Other trace elements	—	—	Minimizing

Reference: P-75 of Journal (No.556: Jan. /2003: TENPES

Table- 9: Quality standard for plaster board

			Quality standard (limit values)	Quality standard (effort target values)
Gypsum dehydrate	Moisture adhering	%	< 10	< 8
	Sulfate (SO_3)	%	> 44	> 45
	Free carbon	—	White color more than equal to No.5 color swatch	White color more than equal to No.3 color swatch
	Calcium carbonate ($CaCO_3$)	%	—	< 1
	Calcium sulfite ($CaSO_3 \cdot 1/2H_2O$)	%	—	Minimizing
	Sodium oxide (Na_2O)	%	< 0.03	< 0.01
	Other trace elements	—	—	Minimizing
	pH	—	5 ~ 7	5 ~ 7
	Crystal size (width) (length)	µ	—	30 ~ 70 50 ~ 250
Calcined plaster	Amount of mixed water	%	< 90	70
	Curing time	min	< 40	30
	Wet tensile strength	kg/cm^2	> 80	12.0
	Adhesiveness	—	Be good	Be good
Ratio of bulk density (Gypsum dehydrate/calcined plaster)		—	> 0.9	1.0

Reference: P-76 of Journal (No.556: Jan. /2003): TENPES

2. Relationship between desulfurization system and characteristics of gypsum

   Generally, the significant relationships are not allowed between desulfurization system and gypsum byproduct. The fuel, raw material or operation conditions have large impact rather than system. There are the mixed system with ash and ash separation system as the treatment method of collected dust in desulfurization system. The separation system is suitable when requiring high quality of gypsum and the mixed ash method is suitable when giving priority to economy efficiency, though either method is selected may be dependent on the required quality of gypsum and the economics of desulfurization facility.

Article 207. Ash classification facility

Article 207-1-1. Classification of ash

1. Classification of coal ash

   Coal ash is classified by occurrence and its product as shown in Table-10.

Table- 10: Terms related ash in JIS standard

Terms	Meanings
Cinder ash	Coarse ash generated by combustion
Fly ash	Fine grain ash generated by combustion
Clinker ash	Firmed ash generated by combustion
Bottom ash	Ash dropped into furnace bottom generated by combustion

Reference: P-63 of Journal (No. 556: Jan/2003): TENPES

2. Classification by occurrence

Coal ash is classified by occurrence as shown in Table-11.

Table- 11: Classification depending on generation point

Designation	Occurrence	Ash distribution (%)
Fly ash	Coal ash which is collected from flue gas of pulverized coal-fired boiler by dust collector	About 80～90
Cinder ash	Coal ash which is collected during flue gas of pulverized coal-fired boiler passing through air heater and economizer	About 5%
Clinker ash	Coal ash which fell into furnace bottom and is collected of pulverized coal-fired boiler	About 15～5

Note-1: Fly-ash and cinder ash sometimes collectively referred to as the fly-ash.

Note-2: Bottom as is called clinker ash.

Reference: P-63 of Journal (No. 556: Jan/2003): TENPES

3. Classification of products

Coal ash is classified in 3 types, raw, fine and coarse by product and quality as shown in Table-12.

Table- 12: Classification by products

Designation	Classification by product type	Remarks
Fly ash	Raw fly-ash: fly-ash as it occurred from boiler	JIS standard stipulates fly-ash for concrete in type 1 to 4.
	Fine fly-ash: fly-ash which is recovered in the area of downstream section of dust collector or fine ash after adjustment of particle size	
	Coarse fly-ash: coarse fly-ash after adjustment of particle size	
Clinker ash	There is a type which particle size is adjusted and other type which particle size is not adjusted.	

Reference: P-63 of Journal (No. 556: Jan/2003): TENPES

4. Classification by classifier

The classifier is referred to a device for selecting a range in particle size from the boiler combustion ash (a cinder ash fly-ash) as shown in Table-13.

Table- 13: Type of classifier

Raw fly ash	Ash before entering the classifier
Coarse fly ash	Coarse one of classified ingredients
Fine fly ash	Fine one of classified ingredients

Reference: P-63 of Journal (No. 556: Jan/2003): TENPES

Article 207-1-2. Method of ash classification

1. There are classification processes to classify ash such as a method to using a cyclone or electrostatic separation method and the like.

Article 207-1-3. Ash classification facility

1. Electrostatic classifier

It is known that the unburned carbon contained in coal ash absorb AE (air entering) agent when kneading concrete and make it difficult to manage concrete slump and air flow. If it is possible to manage fly ash less than a predetermined value, it is possible to improve the quality of the concrete admixture.

It can be sorted by type for different particle momentum direction of motion due to the difference in property values, when charged powder is mixed with particles of two or more. Powder is charged by friction charging which particle contacting or collision with vessel wall in the processes to handling powder. Charging polarity due to friction is depending on the components of a substance in contact or collision. Mineral particles and other charged particles are unburned carbon conflicting charges, because of the different physical properties and chemical properties of the particle surface, in case of contact with other mineral particles of unburned carbon in fly-ash. Fig-30 shows a schematic diagram of an electrostatic classifier and the appearance is shown in Photo-16.

The raw material is fed between the parallel electrodes. Each particle of coal ash is charged by friction due to the collision of particles. At this time, unburned carbon particles are charged in plus and mineral particle are in minus. Motion of charged particles can be controlled by an electric field. The charged particles charged in plus are attracted to negative electrode and the charge particle in minus are attracted to positive electrode by the electrostatic force. Mineral particles that are attracted to the positive electrode are moved to the left in Fig-30 and particles that are attracted to the negative electrode are moved to the right as well by rotated lattice belt continuously. The efficient processing performance by single electrostatic classification separation is obtained during transportation by belt, since it means that in a multi-stage separation is carried out by the friction charging and static electric force repeatedly. This electrostatic classification system is running in the three power plants in USA and a power plant in Scotland, total six power plants as of 2002. The standard processing capacity per machine is 30ton/hour.

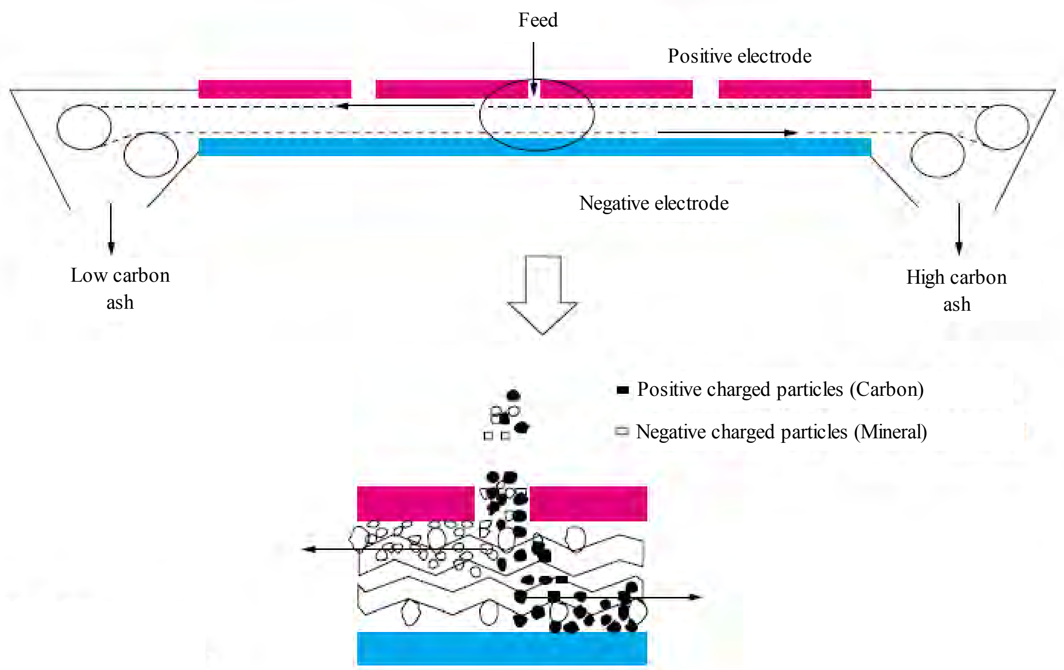


Fig- 30: Scheme of electrostatic separator

Reference: Utilization of Coal Combustion Ash by Electrostatic Separation and Water-permeable Concrete Pavement: KOBE STEEL ENGINEERING REPORTS/Vol. 53 No. 2 (Sep. /2003)

Photo- 16: Photograph of electrostatic separator

Reference: Reference: Utilization of Coal Combustion Ash by Electrostatic Separation and Water-permeable Concrete Pavement: KOBE STEEL ENGINEERING REPORTS/Vol. 53 No. 2 (Sep. /2003)

2. Cyclone classifier

This is the machine to classify fine grain which cannot be separated by conventional sieve by means of It is used for screening such as ore, coal and coal ash as shown in Photo-17, 18, Fig-31 32.

Photo- 17: Ash classifier

http://www.yuno-eg.co.jp/top.jpg

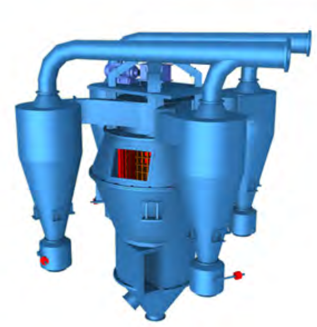


Photo- 18: Ash classifier

http://www.jsynd.com/upload2/475.jpg

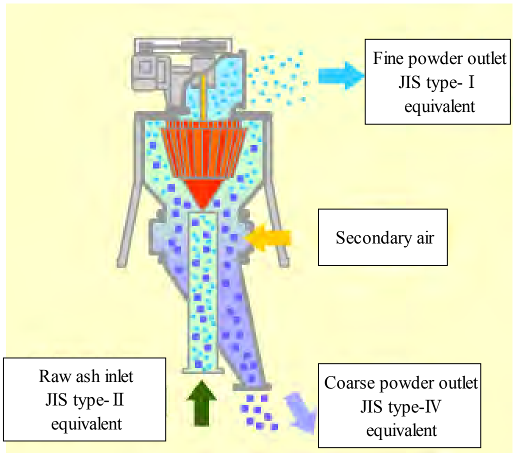


Fig- 31: Ash classifier

http://www.kurimoto.co.jp/powdersystem/product/WhizzerSeparator.html?searchKbn=0&detailsKbn=1

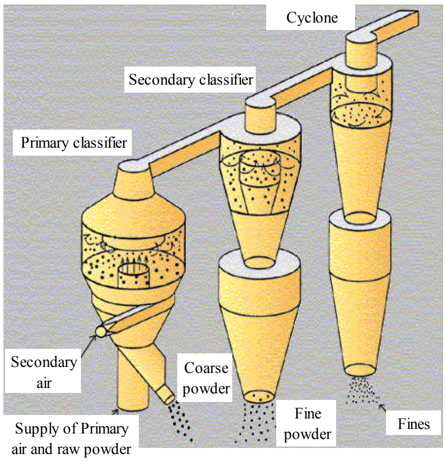


Fig- 32: Ash classifier

http://www.yuno-eg.co.jp/youryo.html

Article 208. Ash storage silo

Article 208-1-1. Requirement for ash storage

1. It is necessary measures to avoid solidification, blocking, bridging and plugging of stored ash in the storage silo. In particular, it is necessary to prevent bridge breaker installed in the silo hopper or providing the aeration equipment to fluidized ash.

Article 208-1-2. Type of ash silo

1. There are two systems to store ash. One is to store ash once from the economizer hopper, air preheater hopper, EP hopper, bagfilter hopper and cyclone hopper and then classification is performed as needed, the other is to store in separate silos without mixing in a fine, medium and coarse particles. The typical ash silo which is made of concrete, steel plate or colgate plate as shown in Photo-19, 20,

21, 22, 23 and 24.

Photo- 19: Fly-ash silo

http://www.younglovellc.com/aspx/ourmarkets/ourmarketdetail.aspx?id=122

Photo- 20: Fly-ash silo

http://www.pneumatyczny.pl/galeria_ang.php?kat=galeria

Photo- 21: Fly-ash silo

http://essesstechnofabs.com/images/big54.jpg

Photo- 22: Fly-ash silo

http://img.alibaba.com/photo/106222310/Steel_Silo_for_Grain_Storage.jpg

Photo- 23: Fly-ash silo

http://c541658.r58.cf2.rackcdn.com/vault/img/2011/08/31/4e5e3845c29e067de200000e/medium_Fly_Ash__STI_Baltimore__MD.jpg

Photo- 24: Fly-ash silo

http://image.tradevv.com/2010/12/13/yongzheng/plant/20101213154201.jpg?size=600

Article 208-1-3. Typical system of ash transportation

1. If it is not capable to load ash from the storage silo to the bulk carrier, ash is transported from the ash storage silo to the shiploader by the air transportation system, the vacuum transportation system or the pipe conveyor as shown in Fig-33.

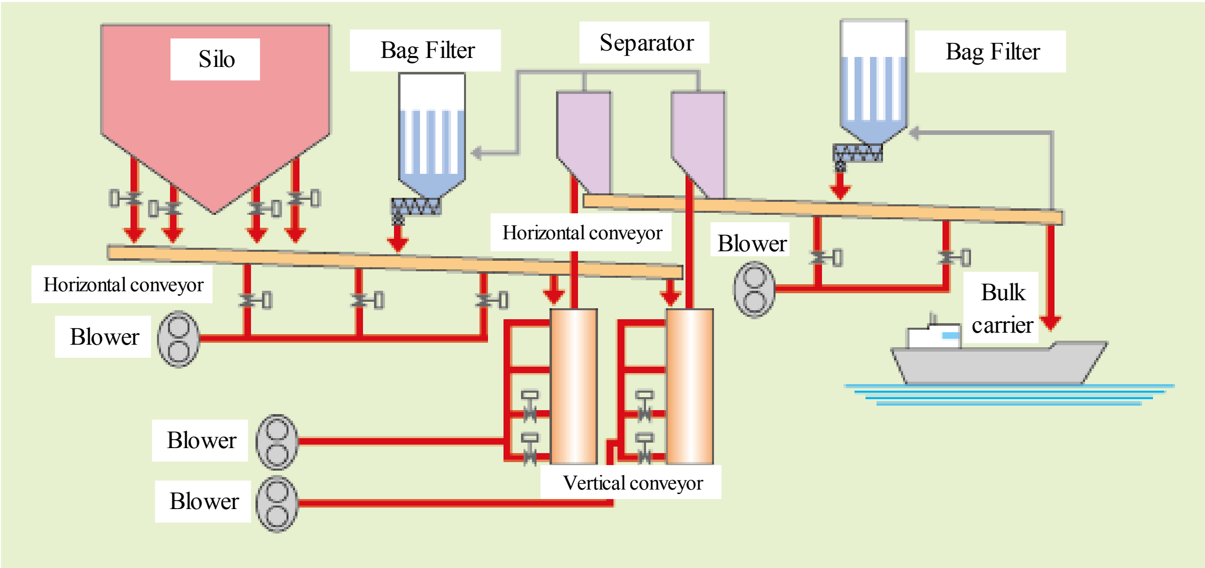


Fig- 33: Ash transportation facility for bulk carrier

http://www.sintokogio.net/funtai/air/img/p04.gif

Article 208-1-4. Aeration equipment

1. Aeration is to blow air into the cone and the bottom of ash silo to prevent blocking, bridging and plugging, and facilitate the move as a liquid state by fluidization as shown in Fig-34, 35, 36, and 37.

Fig- 34: Aeration equipment

http://www.flsmidth.com/~/media/Images/Product-SubSection%20Pages/Storage/Silos/CFI%20silo/CFI_udsnit-1.ashx?mh=325&mw=920

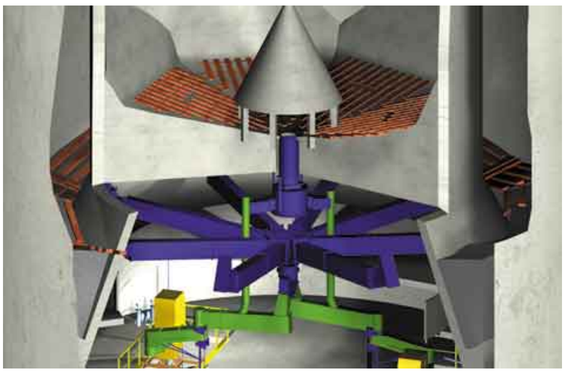


Fig- 35: Aeration equipment

http://www.flsmidth.com/~/media/Images/Product-SubSection%20Pages/Storage/Silos/CFMI%20Silo/CFMI_udsnit-1.ashx?mh=325&mw=920

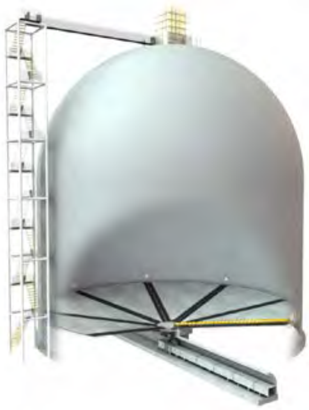


Fig- 36: Aeration equipment

http://www.laidig.com/sites/default/files/imagecache/Large-600/reclaimers/node/images/front%20page%20silo.jp

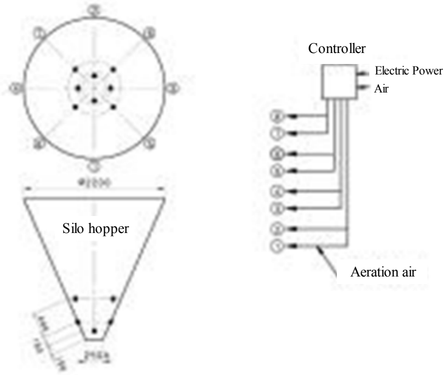


Fig- 37: Bridge breaker

http://www.mi-nagi.co.jp/example/example-big/

Article 209. Ash discharge facility

1. It is capable to transport ash directly by conveyor in case of the power plant adjacent to the cement manufacturing plant However, it is necessary to select appropriate transportation system and corresponding loading facility depending on the absence of ash pond in the premise, location of power plant and the amount of generating ash in other power plant. It is possible to transport large quantity of ash in order transportation by vehicle → transportation by railroad →transportation by bulk carrier.

Article 209-1-1. Ship loader and self unloading carrier

1. In large power plants which has not own ash pond, generated ash is stored everyday and a large quantity of ash is transported in regular basis by bulk carrier. So, the corresponding loading facility is required. The typical ship loader and self unloading bulk carrier is shown in Photo-25 and 26.

Photo- 25: Ash ship loader

http://en.specoplant.com/bbs/files/newse/200804241532585 0941300.jpg

Photo- 26: Self unloading bulk carrier

http://www.nordnes.nl/gallery/kvitnes.jpg

Article 209-1-2. Loader for jet-pack wagon

1. When using railway to transport the ash on the regular basis, while not large quantity enough to ship, pull the railroad truck beside or below the silo, the loading facility required in order to perform efficient loading. The special wagon for powder is used for transportation of ash. The typical unloaded and pack train is shown in Photo-27 and 28.

Photo- 27: Fly-ash loading facility

http://www.flsmidth.com/en-US/Products/Product+Index/All+Products/Loading+and+Unloading/Loading+Systems/Full oad+Railcar+Loading

Photo- 28: Fly-ash pack train

http://livedoor.2.blogimg.jp/koukendaisuki/imgs/f/d/fd6e3986.JPG

Article 209-1-3. Loader for jet-pack trailer

1. The jet-pack truck is used for the transportation of ash from the small and medium sized power plants or which generates not much ash, since it is capable to adjust transportation depending on the amount of ash. Therefore, the loading facility is required under or beside the silo in order to perform efficient loading. The typical unloader is shown in Photo-28, 29 and jet pack trailer is shown in Photo-29, 30, 31 and 32.

Photo- 29: Fly-ash loading facility

http://photos.journalrecord.com/Published-Photos/September2010/13574216_tJ8h3M/1/991164680_iUFLY#991164680_iUFLY

Photo- 30: Fly-ash loading facility

http://www.flsmidth.com/en-us/Products/Product+Index/All+Products/Pneumatic+Transport/Fly+Ash+Handling/Dry+Intercept+System

Photo- 31: Fly-ash transporter

http://bulktransporter.com/photo_galleries/bulk-first-llc-0128/

Photo- 32: Jet pack trailer

http://image.kurumaerabi.com/image/00/09/74/00097437.jpg

Photo- 33: Fly-ash dustless chute

http://1.bp.blogspot.com/_6S1wBZDE9ZM/S_DW4XYZD7I/AAAAAAAAAc8/3GCfRpFBAPQ/s1600/140510-1020.jpg

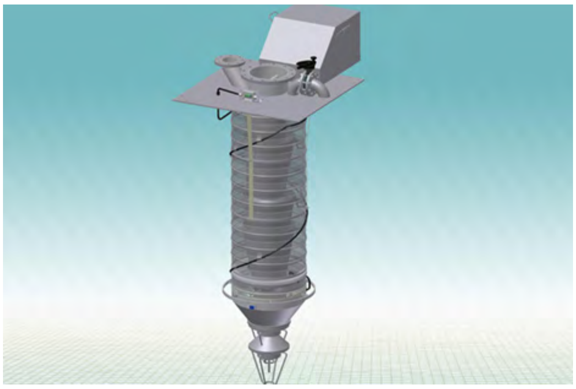


Photo- 34: Fly-ash dustless chute

http://www.flsmidth.com/~/media/Images/Product-SubSection%20Pages/Material%20Handling/Moeller%20Images/03Loading1.ashx?mh=325&mw=920

Article 209-1-4. Loader of wet ash for dump track

1. When the open dump truck is used, the loading facility to humidize to slurry in order to prevent scattering of ash is required. The typical conditioner is shown in Photo-36, 37, 38 and transporter is shown in Photo-35.

Photo- 35: Wet ash transporter

http://www.somakankyo.co.jp/unyu.html

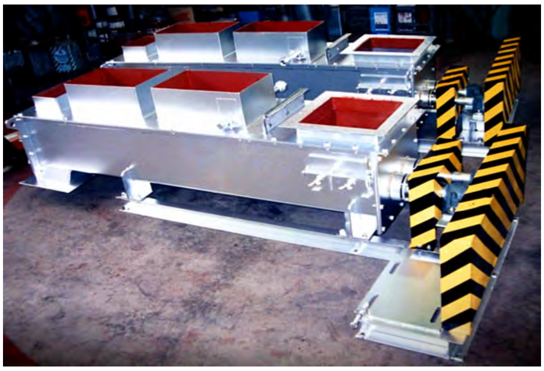


Photo- 36: Conditioner

http://chascon.co.jp/img/products_img/s_conveyor_img/s_conveyor06_l.jpg

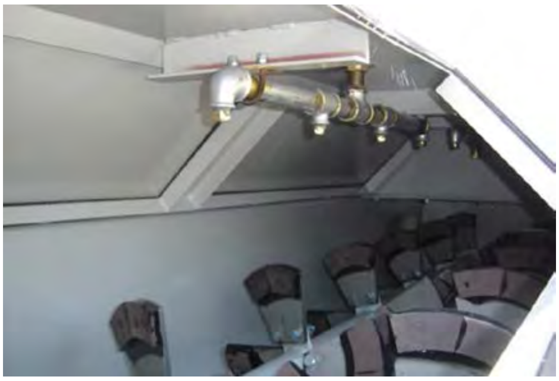


Photo- 37: Conditioner

http://www.processbarron.com/ash-handling-equipment/ash-conditioners-unloaders

Photo- 38: Conditioner

http://www.processbarron.com/ash-handling-equipment/ash-conditioners-unloaders

Article 210 General provision of ash dump

1. The ash disposal facility is divided into two, the landfill facility in the premise and unloading facility to outskirt (such as dry ash loading facility to truck, dry ash loading facility to ship, wet ash loading facility to truck and wet ash loading facility to ship). Ash landfill facility in the premise is composed of two systems, the clinker ash landfill system and fly-ash landfill system, the fly-ash is accounting for most of amount.
2. It has been required to contribute together with the effective use of resources and reducing generation of waste and environmental protection, since disposal of the waste by conventional process or treatment reached limit due to increased waste generation, lack of disposal area depending on the economic growth in recent years due to the improvement of people's lives. "Law for promotion of utilization of recycle: Recycle Law" was enacted to deal with these issues in Japan.

   Coal ash is recycle resources referred to in this Law (meaning goods that are useful, obtained due to the energy supply side, what can be used as raw materials, the potential thereof) of those, in addition, coal ash that is generated from the power plant supplying 120 million kWh per year (approximately

20MW) as by-product is designated as recycle resources in particular.
In addition, effective use of coal ash is stated in “Policy for the promotion of utilization of recycled resources” (promulgated on October/1991) as follows;

“It is necessary to expand further use as the renewable resource, although coal ash generated during combustion of coal is used as raw material for cement. For this reason, the operator belonging to the electrical industry must endeavor to the promotion of products according to standard specifications, to develop processing equipment necessary to perform effective as renewable resources, to expand application and to develop technically to improve the quality. “

In addition, it is necessary to grasp the relationship between “Waste and public cleaning law”, since coal ash is designated as industrial waste. The law is not fully applied to coal ash, it is applied by being whether valuable material or not. Criteria to judge as valuable resources could depend on whether “trading to others with fee” or not and stipulated as follows;

To sale and paid means that “the owner passes the goods to the trading partner and receives the proceeds substantially.” An illegal sale or formally charged are not allowed. Unwanted materials produced during the handling of valuables are true in industrial waste, and then the law applies even if it is valuable.

From the above, it is important to endeavor using coal ash as a useful resources with the viewpoint of whether valuable resources or waste in dealing coal ash.

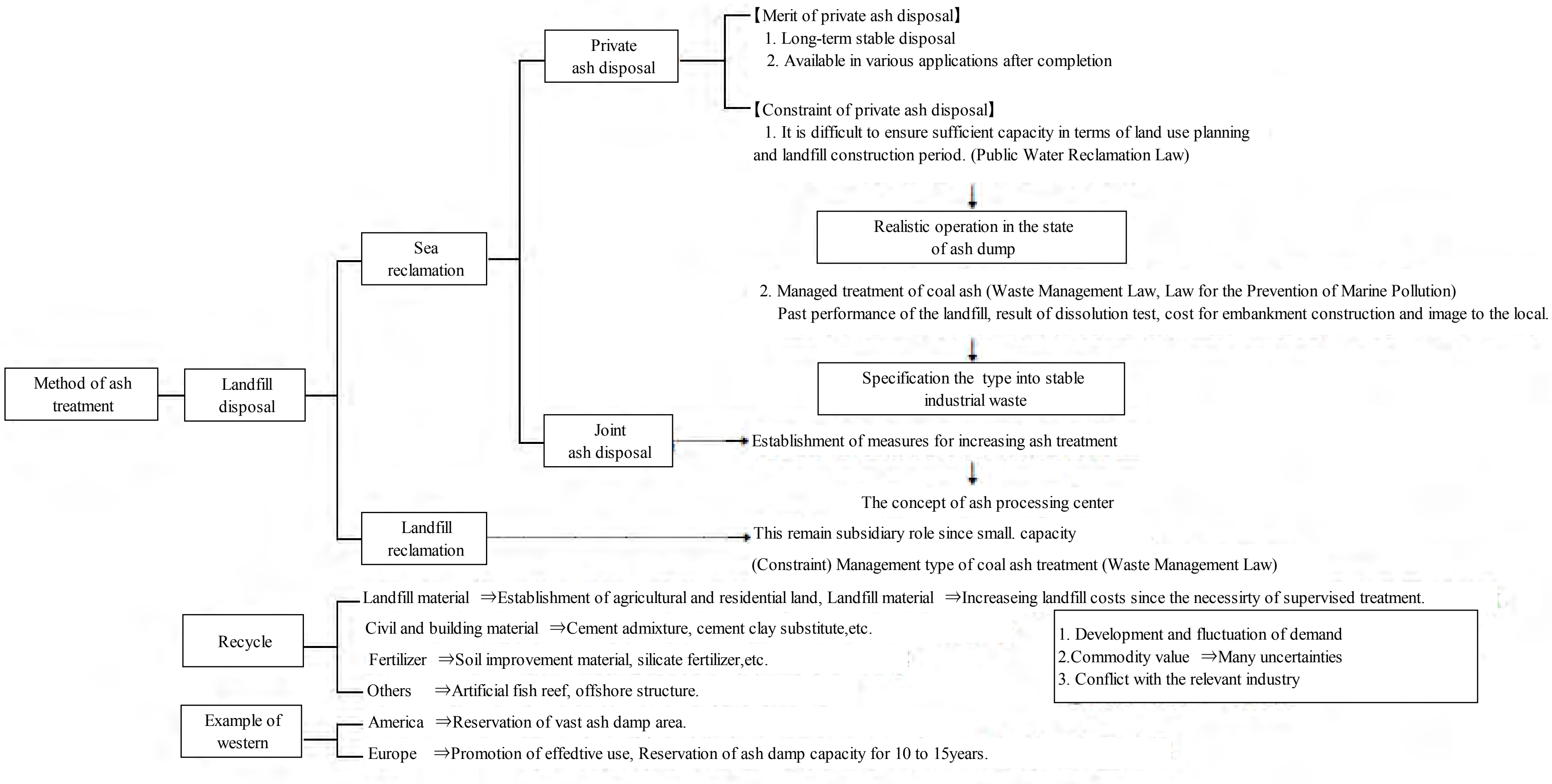


Fig- 38: Coal ash handling system

Reference: P-67 of Journal (No. 556: Jan/2003): TENPES

Article 211. Off-shore disposal

1. The system for landfill by clinker ash has been selected considering the geographic location of power plant from several method which flowing away directly to ash pond, transporting from clinker storage bin or dewatering tank by truck or transporting by belt conveyor as shown in Fig-38, Table-14. The direct disposal by the low density slurry landfilling had previously been employed because it is simple system, however, the high density slurry landfilling or wet ash landfilling is adopted in considering the advantage of less impact on the surplus water from the ash pond.

   Particularly, the high density slurry landfilling can be expected to be widely adopted in the future, since it is possible to survive ash pond life and apply the automatic operation. The unloading facility for the transportation to off-premise is selected depending on the conditions of receiver in any event, while there are many choices either humidified or dry condition, railway, truck or ship, etc. It is common to carry out in the dry state in case for the effective use and in wet state in case for the disposal.

   Recently, the loading facility for bulk carrier is often planned for mass transportation by ship in order to support the effective use of large amount of ash in the cement industry increased generated volume. The compressed air transportation system is commonly adopted for loading of dry ash to ship on the layout by taking advantage of mass transportation capacity by pipeline. Belt conveyor is used for loading of wet ash to shop which is suitable for mass transportation. Recently, the pipe conveyor has become been adopted as conveyor belt, although the traditional flat belt can be employed since it is recognized advantages such as placement in curve or less drop of ash on return side.

   When adopting the belt conveyor, it is essential for coordinated planning and considering other power plant equipment because of the nearly linear arrangement. In particular, it is important to consider rational planning and coordination of transportation facilities for gypsum as well as ash. As an example, the loading conveyor for gypsum and the wet ash conveyor are used as both, or the space-saving by arrangement in same place. In addition, it will be expected to cooperative and rational arrangement in considering wharf sharing by dry ash carrier, wet ash carrier and gypsum carrier or loading facility.

Table- 14: Fly-ash landfilling system

	High density slurry landfilling	Low density slurry landfilling	Wet ash landfilling
Summery	Ash is mixed with sea water to slurry and transported to disposal pond by pump and pipe directly into the sea.	Ash is transported by water ejector provided at the end of vacuum transportation piping. Fly-ash and water are mixed in the water ejector, and transported to the ash pond by gravity flow through the pipe and is discharged directly into the ash pond. The clinker disposal pump is also used as the water pump to drive the ejector pump.	Ash is added water by dustless unloader to prevent scattering, loaded into dump truck or conveyor, transported to disposal area and pressed by bulldozer.
Water content (water/ash)	about 50%	about 300%	about 20%
Landfill density (survival of ash pond)	1.1 ~ 1.2t/m^3	0.9 ~ 1.0t/m^3	0.9 ~ 1.0t/m^3
Strength of landfill soil	It may become unnecessary when using the site of ground improvement, since high strength of landfill soil.	It is not expected enough strength, and must be available upon the site of soil improvement.	It is not expected enough strength, and must be available upon the site of soil improvement.
Ash floating	Trace	Large amount of floating ash causes on the sea level	Large amount of floating ash causes on the sea level
Ash scattering	Almost no scattering of ash.	Some scattering of ash.	Much scattering of ash and must be covered with soil immediately.
Impact on water quality in landfill area	small	big	small
Operability	Daytime operation is general rule; however, it is possible to operate at night or holiday. Remote centralization management is possible.	It is possible continuous operation day and night. Remote centralization management is possible.	Landfill operation is possible in the daytime. In addition, it is stopped on holiday. The worker is necessary constantly.

Reference: P-94 of Journal (No.445: Oct. /1993): TENPES

2. Photo-39 is the completed bank for the coastal power plant to landfill by coal ash. After the commercial operation, sea water area is landfilled by the high density, low density slurry or wet ash as shown Photo-40, 41, 42.

Photo- 39: Ash Disposal Pond

http://www.aisawa.co.jp/works/works12_8.html

Photo- 40: High Density Slurry Disposal

http://www.powerofpeace.com/files/images/Power-plant%20ash%20disposal%20field%20in%20Serbia.preview.jpg

Photo- 41: Low Density Slurry Discharge

http://www.greenpeace.org/usa/community_images//54/34954/11125_19063.jpg

Photo- 42: Low Density Slurry Discharge

http://ecocrete.eu/images/life_cycle_analysis_of_oil_shale_industry_Page53.jpg

3. Management of surplus water quality from ash pond

   It is necessary to recycle water for slurry and the surplus water and rain water must be discharged from ash pond after treating according to the effluent standard as shown in Table-15.

Table- 15: Effluent standard of effluent from ash pond

Drainage Item	Unit	Effluent standard of effluent from ash pond
Appearance	—	
Turbidity	—	
Alkyl mercury compound	mg/l	No detectable
Mercury or its compounds	mg/l	0.005 >
Cadmium or its compounds	mg/l	0.1 >
Lead or its compounds	mg/l	0.1 >
Organophosphorous compound	mg/l	1>
Hexavalent chromium compound	mg/l	0.5 >
Arsenic or its compounds	mg/l	0.1 >
Cyanogen	mg/l	1 >
Polychlorinated biphenyls	mg/l	0.003 >
Trichlorethylene	mg/l	0.3 >
Tetrachlorethylene	mg/l	0.1 >
Dichloromethane	mg/l	0.2 >
Carbon tetrachloride	mg/l	0.02 >
1.2-dichlororthane	mg/l	0.04 >
1.1-dichloroethylene	mg/l	0.2 >
Cis-1.2-dichloroethylene	mg/l	0.4 >
1.1.1-trichloroethane	mg/l	3 >
1.1.2-trichlororthane	mg/l	0.06 >
1.3-dichloropropene (D-D)	mg/l	0.02 >
Thiuram	mg/l	0.06 >
Simazine (CAT)	mg/l	0.03>
Chiobenkarupu (Benchiokapu)	mg/l	0.2 >
Benzene	mg/l	0.1 >
Selenium or its compounds	mg/l	0.1 >
Cntent of n-hexane extract (mineral oil, etc.)	mg/l	5 >
Cntent of n-hexane extract (animal and plant oils)	mg/l	30 >
Phenolic content	mg/l	5 >
Copper content	mg/l	3 >
Zinc content	mg/l	2 >
Soluble iron content	mg/l	10 >
Soluble manganese content	mg/l	10 >
Chromium content	mg/l	2 >
Fluorine content	mg/l	15 >

Drainage Item	Unit	Effluent standard of effluent from ash pond
Boron content	mg/l	230 >
Phosphorus content	mg/l	2.41 >
Nitrate-nitrogen, Nitrite-nitrogen and Ammonium-nitrogen	mg/l	60 >
Nitrate-nitrogen	—	—
Nitrite-nitrogen	—	—
Ammonium-nitrogen	—	—
Total nitrogen	mg/l	19.9 >
Coliform count	piece/cm^3	3,000 or less in daily average
Dioxins	Pg-TEQ/L	10 >

Reference: http://www.kyuden.co.jp/var/rev0/0037/4115/1107_reihoku.pdf

Article 212. On-shore disposal

Article 212-1. Recycle of ash

1. Advantage of fly-as

   Fly-ash has the advantage as listed in the Table-16.

2. Quality and status of effective utilization of coal ash

(1) Quality standard of fly-ash

The raw coal ash powder, etc. are adjusted the granularity classifying by classifier and is commercialized to products.

The fly-ash is classified in type-1, type-2, type-3 and type-4 according to JIS A6201 as shown in the Table-17.

(2) Status of effective utilization of coal ash

The fly-ash is classified in type-1 to type 4 and is used for the concrete admixture which is used for building construction, dam construction, and road paving. In addition, fly-ash is used as the soil improvement material for ground, soccer fields and park, etc. and fertilizer because of the water retention, drainage and breathability. The status of efficient use of coal ash is shown in Table-18.

(3) Development of effective utilization technology of coal ash

Fly-ash and clinker-ash is often used as a raw material for cement. It is necessary to develop further development of new strategies of coal ash utilizing the characteristics coal ash in order to enhance the effective use.

Table- 16: List for advantage of fly-ash

Advantage	Description
Enhancement of long-term strength	It can be obtained lasting structure because of improvement of long-term strength than the cement alone by long-term continuation pd Polazon reaction, if mixing fly-ash with cement.
Inhibition of alkali/silica reaction	The concrete which is mixed a certain amount of fly-ash have has the effect to suppress against alkali-silica reaction (reaction of nature to inhibit sodium silicate).
Reduction in drying shrinkage	The concrete or mortar which is mixed fly-ash have strong structure as well as a decrease in cement content of fly-ash replacement rate increases, since the reduction of the unit water content, decreases the rate of shrinkage after curing, the structural cracks and robust phenomenon hardly occurs.
Deduction in the heat of hydration	If mixing fly-ash in the cement, the hydration heat of concrete decreases. Because temperature decreases with increasing replacement rates, etc. it is very effective to the construction of dam and the containment vessel, etc.
Increased watertightness	If mixing fly-ash in the cement, free coal in the cement bonds with silica and alumina in the fly-ash, building hard insoluble material and dense tissue of concrete and the effect over time increases the strength. It is effective to underground works and wet construction.
Improved liquidity	It can be smooth and beautiful finished surface by the improvement of liquidity, mixing, concrete settling and gap filling; fly-ash has a fine spherical shape.

Note: The Polazon reaction is the reaction to produce no hydraulic silica and calcium hydroxide and to generate insoluble silica.

Reference: P-72 of Journal (No.609: June/2007): TENPES

Table- 17: Quality standard of fly-ash (JIS A6201-1999)

item	type	Type-1	Type-2	Type-3	Type-4
Silicon dioxide (%)		40.0 and more			
Moisture (%)		1.0 or less			
Ignition loss (%) (1)		3.0 or less	5.0 or less	8.0 or less	5.0 or less
Density (g/cm^3)		1.95 and more			
Fines (2)	45μm sieve residue (sieve method) (%) (3)	10 or less	40 or less	40 or less	70 or less
	Specific surface area (Blain method) (cm^2/g)	5,000 and more	2,500 and more	2,500 and more	1,500 and more
Flow ratio (%)		105 and more	95 and more	85 and more	75 and more
Activity index (%)	28 days aging	90 and more	80 and more	80 and more	60 and more
	91 days aging	100 and more	90 and more	90 and more	70 and more

Remarks-1: The fuel carbon content value measured by the method prescribed in JIS R1603 or JIS M8819 may be applied instead of the loss on ignition to the provision of the ignition loss.

Remarks-2: The fines must be determined according to the sieve mesh method or Blain method.

Remarks-3: In case applying fines according to sieve method, the testing result of specific surface area according to brain method must be written for reference.

Reference: P-64 of Journal (No. 556: Jan/2003): TENPES

Table- 18: Efficient use of coal ash

Classification	Method for use	Purpose to use
Type-1	Concrete admixture	Building, dam, pile, etc.
	Shotcrete	Cut earth slope, etc.
	Color pavement	Road and pavement, etc.
	Concrete secondary products	Channel, culvert, etc.
Type-2	Concrete admixture	Building, dam, pile, etc.
	Lightweight fill material	Filling for road expansion, etc.
Type-3	Concrete admixture	Building, dam, pile, etc.
	Lightweight fill material	Filling for road expansion, etc.
Type-4	Concrete admixture	Building, dam, pile, etc.
	Lightweight fill material	Filling for road expansion, etc.
	Asphalt filler	Filler material for asphalt pavement
Clinker ash	Soil improvement material, fertilizer	Ground, football ground, green park, etc.

Reference: P-73 of Journal (No.609: June/2007): TENPES

3. Specific target of effective use

3.1. Domain of cement

3.1.1. For raw material of cement

The raw materials required for production of cement is 1) clay, 2) silica and 3) iron oxide. It can be used as an alternative, since coal ash is largely of clay, although silica clay (Sio^2) or shale of the high content of siliceous is used for clay.

Generally, the silica content of coal ash is lower than the raw clay for cement, it is necessary to supplement by silica. Therefore, the limit of use of coal ash have been seen about 10~20% of clay. However, coal ash is used as an alternative more than half of the total effective utilization, because there are no significant constraints on the quality of coal ash when using as an alternative to use of clay. The transportation of coal ash to cement plant from coal-fired power plant is done by the bulk carrier, jet-pack truck or pipe conveyor depending on the location.

3.1.2 For fly-ash cement

The fly-ash cement is the mixed cement which is mixed cement with fly-ash. The fly-ash cement which is specified in JIS R5213 is suitable for dam that needs mass concrete, since it has good fluidity under relatively small amount of water, can be cast concrete easily; it is possible to reduce the drying shrinkage and heat of hydration. The standards are divided into three types as shown Table-13, the fly-ash which specified in JIS R6201 (fly-ash) is determined to be limited to so-called JIS standard ash. The amount of fly-ash cement production has been decreasing since 1988; the total production of the cement production has been less than 1%.

3.1.3. For ready-mixed concrete

The mixture of fly-ash in manufacturing ready-mixed concrete, the same advantage s is obtained in the case of fly-ash cement. However, the amount of ready-mixed concrete used is about 160,000ton/year as of 1991, and very little has remained compared with shipment of cement-mixed concrete (57,220,000ton).

3.2 Domain of civil engineering

3.2.1 For civil works

The concrete using fly-ash cement has been used extensively in civil engineering for structures. In recent years, the RCD concrete has been focused. This is the mechanized method of consolidating tighten vibrating roller (RCD method: Method Roller Compacted Dam) after scattering very tightly kneaded concrete. It is necessary to suppress the heat of hydration without cooling of pipes. The use of fly-ash is valid for this, cement added 20~30% of fly-ash is used for RCD concrete.

3.2.2 For soil improvement

The applications of coal ash have been developed as ground stabilization materials, soil reinforcement and mainly improvement material for soft ground.

3.2.3 For roadbed material

Roadbed is generally called the lower portion of paving and is constructed by compacting applied durable material. Roadbed is distributed in the upper and lower base; the coal ash is utilized to lower base. The clinker ash has been adopted as the underlayer base material as the result of various tests in "Outline of Asphalt Pavement" revised in 1988 by Japan Highway Association.

3.2.4 For asphalt filler

Contrary to the roadbed, the most superficial layer is called the paved portion and the direct under it called the substratum. In case of asphalt pavement, a mix of asphalt and aggregate is used in this part, and filler material is used to charge the cavity walls of the asphalt mixture. It has been confirmed that fly-ash has the same performance as lime stone powder as filler material as the result of various tests. Therefore, fly-ash is adopted as asphalt filler material as well as clinker ash in roadbeds in "Outline of Asphalt Pavement" revised in 1988 by Japan Highway Association.

3.3 Domain of aggregate

3.3.1 Artificial lightweight aggregate

The technology which mix fly-ash with pulverized coal and granulated, fired and produce the artificial lightweight aggregate, it has been sold after certifying by Ministry of Construction of Japan in 1985.

3.4 Domain of architecture

3.4.1 For wall material

If applying coal ash for a part of interior or exterior wall, it is expected to improve fire-resistance, heat insulation and dimensional stability. Currently, pulp cement board, calcium silicate board and slag cement board is commercialized as the wall material using coal ash. It is preferable ensure whiteness as possible, because the color is most important when utilizing coal ash into the wall material.

3.4.2 For secondary concrete products

The secondary concrete products is the hume pipes, wave absorbing P block, aerated concrete block (ALC: Autoclaved Lightweight Concrete) products, etc. which are solidified products, coal ash is applied under the essentially similar concept to normal concrete.

3.4.3 Gypsum board

The amount of desulfurization gypsum is expected to increase, since the coal-fired power plant to increase and from the fact that economic stability and excellent fuel supply. In recent year, domestic cement production in Japan tend to be gradually decrease, it is necessary to increase the efficient use of materials other than raw material for cement and gypsum board.

3.5 Domain of fisheries and agricultural

3.5.1 For fertilizer

Coal ash itself is designated as a special fertilizer in Fertilizer Control Law in Japan. The content of specifications is as follows;

“Pulverized coal-fired ash (molten pulverized coal combustion ash which is collected from flue gas flow or bottom of furnace in the thermal power plant. However, the ash taken from bottom of furnace is limited to the opening of the whole of the 3mm sieve.)”

This is sold as goods in Japan, 100,000ton/year are available temporary, and now it is about 10,000 to 20,000ton per year.

The current mainstream is potassium silicate fertilizer. This is fired coal ash adding potassium hydroxide and magnesium hydroxide, and has the characteristics of less leaching and sustained effect of fertilizer, since the silica in coal ash bonds with potassium and generates a component un-soluble into water. It has been recognized the fertilizer effect on test results compared to conventional fertilizers such as increased yield, improvement of quality, reduction of soil disease due to continuous cropping. Currently, it has been sold several hundred per year.

3.5.2 For soil improvement material

The effect is expected to improve the physical properties such as breathability and water retention, the chemical properties of soil such as pH and retention of fertility. In addition, some examples the babies breath is growing by the ridging which is granulated coal ash and special processing, although it is not soil improvement material.

Article 212-2. Final disposal of remaining ash

1. The non-recyclable ash emitted from power plants located inland is likely to perform at the landfill for final disposal on land. In this case, the confirmation that there is no elution of hazardous substances must be done properly. In addition, the illegal dumping after being sold as the valuable resource should be avoided.
2. The licensing for the landfill of sea or lake and disposal of waste material should be pursuant to the law and regulation of Vietnam.

Table- 19: Off-premise transportation system

		Carry out with the dry ash status		Carry out with the wet ash status	
		By truck	By ship	By truck	By ship
Outline	Clinker Ash	—	—	Ash is loaded into dump trucks or directly from clinker ash bin or dewater machine and transported to the outskirts customer or disposal site.	An ash is loaded by conveyor from ash-bin or dewaters equipment into bulk carrier by shiploader installed at berth and transported to the outskirts customer or disposal site.
	Fly Ash	Ash is loaded into jet-pack truck through loading equipment under the silo and transported to the outskirts customer.	Ash is transported by air transportation equipment from silo to shiploader. The shiploader catches fly-ash and loads it to carrier.	Ash is added water by dustless unloader installed under the silo and loaded into dump truck, transported to the outskirts customer or disposal site.	Ash is added water by dustless unloader installed under the silo and loaded into bulk carrier by conveyor, shiploader and transported to the outskirts customer or disposal site.
Ash treatment		Clinker: — Fly-ash: Efficient use	Clinker: — Fly-ash: Efficient use	Clinker: Disposal or Efficient use Fly-ash: Efficient use	Clinker: Disposal or Efficient use Fly-ash: Efficient use
Transport capacity		Small (10t/h vehicle)	Large (1,000~2,000t ship)	Small (10t/h vehicle)	Large (1,000~2,000t ship)

Reference: P-95 of Journal (No.445: Oct. /1993): TENPES

Photo- 43: Wet ash for landfilling

http://www.earthman.tv/2004/forums/images/trashtoenergy/ashtruckdumping.JPG

Photo- 44: Landfilling by ash

http://graphics8.nytimes.com/images/2009/08/30/us/30ash.span.600.jpg

Photo- 45: Landfilling by ash

http://redrena.files.wordpress.com/2008/05/bulldozer-levelling-the-ash-in-one-of-the-cell.jpg

Photo- 46: Coal ash pond

http://1.bp.blogspot.com/_5Xy0Pp1S8qY/TSY9DysrhKI/AAAAAAAAAWk/JY3UaRQtCCk/s1600/coal+ash+pond.jpg

Chapter-3. Reference International Technical Standards

The reference international standards for designing ash handling facility are organized in Table-20.

Table- 20: Reference international technical standards

Number	Rev.	Title	Content
ISO 11723	2004	Solid mineral fuels -- Determination of arsenic and selenium -- Eschka's mixture and hydride generation method	This specifies a method using Eschka's mixture during ashing, extraction of the ash residue with acid, and hydride generation atomic absorption spectrometry or hydride generation atomic fluorescence spectrometry, for the determination of arsenic and selenium in coal and coke ash.
ISO 11724	2004	Solid mineral fuels -- Determination of total fluorine in coal, coke and fly ash	This specifies a method for the determination of total fluorine in coal, coke and fly ash.
ISO 23380	2008	Selection of methods for the determination of trace elements in coal	This provides guidance on the selection of methods used for the determination of trace elements in coal and coal ash. The trace elements of environmental interest include arsenic, beryllium, boron, cadmium, chlorine, chromium, cobalt, copper, fluorine, lead, manganese, mercury, molybdenum, nickel, selenium, vanadium and zinc. To this list can be added the radioactive trace elements, thorium and uranium.
ASTM C271 -64	1965		
ASTM C311 -11a		Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland-Cement Concrete	These test methods are used to develop data for comparison with the requirements of Specification C618. These test methods are based on standardized testing in the laboratory and are not intended to simulate job conditions.
ASTM C593 -06	2011	Standard Specification for Fly Ash and Other Pozzolans for Use With Lime for Soil Stabilization	This specification covers the qualification of fly ash and other pozzolans for use with lime in plastic, non-plastic mixtures and other

Number	Rev.	Title	Content
			mixtures that affect lime pozzolanic reaction required by soil stabilization. Evaluation of pozzolans containing available lime, such as Class C fly ash, is given consideration. Pozzolans covered include artificial pozzolans such as fly ash, and natural pozzolans, such as diatomite and pumicite, in either raw or calcined state.
ASTM C618 -08a		Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete	This specification covers coal fly ash and raw or calcined natural pozzolan for use in concrete where cementitious or pozzolanic action, or both, is desired, or where other properties normally attributed to fly ash or pozzolans may be desired, or where both objectives are to be achieved. Fly ash and natural pozzolans shall conform to the prescribed chemical composition requirements and physical requirements. The materials shall be tested for fineness, strength activity index, water requirement, soundness, and autoclave expansion or contraction.
ASTM C618 -12		Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete	This specification covers coal fly ash and raw or calcined natural pozzolan for use in concrete where cementitious or pozzolanic action, or both, is desired, or where other properties normally attributed to fly ash or pozzolans may be desired, or where both objectives are to be achieved. Fly ash and natural pozzolans shall conform to the prescribed chemical composition requirements and physical requirements. The materials shall be tested for fineness, strength activity index, water requirement, soundness, and autoclave expansion or contraction.

Number	Rev.	Title	Content
ASTM D1757 -03	2009	Standard Test Method for Sulfate Sulfur in Ash from Coal and Coke	This test method pertains to the determination of sulfate sulfur in coal or coke ash. Formerly under the jurisdiction of Committee D05 on Coal and Coke, this test method was withdrawn in October 2009.This standard is a classical gravimetric sulfate method that is sometimes improperly cited for use in contracts. In addition the Eschka's Mixture that is vital for the test method is no longer available commercially.
ASTM D5759 -95	2005	Standard Guide for Characterization of Coal Fly Ash and Clean Coal Combustion Fly Ash for Potential Uses	1.1 This guide recommends standards for the characterization of fly ash from the combustion of coal, fly ash from coal combusted in the presence of alkaline materials, and fly ash from combusted coal in which the flue gases have been treated with alkaline materials in the presence of the fly ash. 1.2 This guide provides recommended and optional test methods for fly ash evaluation. Acceptance criteria can be negotiated between the producer and the user according to the potential end use. 1.3 The coal fly ash and clean coal combustion fly ash of this guide do not include the following: 1.3.1 Dusts from kilns producing products such as lime, portland cement, activated clays, etc.; 1.3.2 By-products of flue gas desulfurization that are not collected with the primary fly ash removal equipment such as the baghouse or

Number	Rev.	Title	Content
			electrostatic precipitator; and 1.3.3 Fly ash or other combustion products derived from the burning of waste; municipal, industrial, or commercial garbage; sewage sludge or other refuse, or both; derived fuels; wood; wood waste products; rice hulls; agriculture waste; or other non-coal fuels or other such fuels blended with coal, or some combination thereof. 1.4 Fly ash may contain some trace elements that may affect performance or potential end use. 1.5 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.
ASTM E1266 -88	2005	Standard Practice for Processing Mixtures of Lime, Fly Ash, and Heavy Metal Wastes in Structural Fills and Other Construction Applications	This practice provides descriptions and references of existing test methods and commercial practices relating to the processing of lime, fly ash, and heavy metal wastes in construction applications. This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.
ASTM E2277 -03		Standard Guide for Design and Construction of Coal Ash Structural Fills	1.1 This guide covers procedures for the design and construction of engineered structural fills using coal fly ash, bottom ash, or ponded ash. 1.2 The utilization of coal ash under this

Number	Rev.	Title	Content
			guide is a component of a pollution prevention program; Guide E 1609 describes pollution prevention activities in more detail. Utilization of coal ash in this manner conserves land, natural resources, and energy. 1.3 This guide applies only to fly ash and bottom ash produced primarily by the combustion of coal. 1.4 The testing, engineering, and construction practices for coal ash fills are similar to generally accepted practices for natural soil fills. Coal ash structural fills should be designed using generally accepted engineering practices. 1.5 Laws and regulations governing the use of coal ash vary by state. The user of this guide has the responsibility to determine and comply with applicable requirements. 1.6 The values stated in inch-pound units are to be regarded as the standard. The SI units given in parentheses are for information only.
ASTM D5239 -04		Standard Practice for Characterizing Fly Ash for Use in Soil Stabilization	This practice is intended for use with fly ash that can be used separately or along with other stabilizing admixtures to improve soil properties. The characterization of the physical and chemical properties of the fly ash shall assist in the evaluation of the fly ash for soil stabilization. This practice is not intended to limit the

Number	Rev.	Title	Content
			flexibility of design in soil stabilization. The degree of success attained in soil stabilization is highly dependent on the particular combination of soil, fly ash, and other additives and the construction procedure used. Demonstrated sound engineering procedures that result in appropriate physical characteristics are acceptable. The selection of appropriate materials, applicable tests, acceptance criteria, and specification is the responsibility of the design engineer.

Chapter-4. Reference Japanese Technical Standards

The reference Japanese industrial standards for designing coal ash handling are organized in Table-21.

Table- 21: Reference Japanese technical standards

Number	Rev.	Title	Content
JIS A6201	2004	Fly ash for use in Concrete	This stipulates fly-ash used as admixture material with concrete or mortar.
JIS B8815	2007	Method for Analysis of Coal Ash and Coke Ash	This stipulates how to analyze the kind of ash of coal and coke.
JIS B8824	2004	Sample preparation – Dispersing procedure for powders in liquids	This stipulates how to adjust the distribution the sample in order to measure the particle size of powder materials.
JIS B9909	2007	Expression of the specification for dust collectors	This stipulates the specifications for how to represent dust collector used to separate particles in the gas collection treatment.
JIS R5213	2009	Portland fly-ash cement	This stipulates fly-ash cement.
JIS Z8832	2010	Determination pf particle size distributions—Electrical sensing zone method	This stipulates about how to measure the particle size distributed in the electrolyte according to the electrical sensing zone method. This is base on ISO 1339.
JIS Z8901	2010	Test powders and test particles	This stipulates about test particle which is used for test such as dust collector or air filter, function test of various instruments, calibration of automatic light scattering particle counter which is used for abrasion test, particle collection efficiency test of ultra-high performance air filter, test particle which is used calibration of automatic suspended particle counter.

Chapter-5. Reference TCVN

The reference Vietnamese national standards for designing coal ash handling are organized in Table-22.

Table- 22: Reference TCVN

Number	Rev.	Title	Content
TCVN 7987	2008	Solid mineral fuels. Determination of total fluorine in coal, coke and fly ash	Tiêu chuẩn này quy định phương pháp xác định tổng flo trong than, cốc và tro bay.
TCVN 8262	2009	Fly ash. Methods of chemical analysis	Tiêu chuẩn này quy định phương pháp phân tích hóa học cho tro bay.

Chapter-6. Referenced Literature and Materials

The referenced books, literatures, standards to establishing this guide line are organized as follows.

1. Interpretation of technical regulation for thermal power facility(10/Jul/1007): NISA (Nuclear and Industrial Safety Agency) of METI (Ministry of Economy, Trade and Industry)
2. Development of coal ash quality control system (Journal No.478: Jul./1996): TENPES (Thermal and Nuclear Engineering Society of Japan)
3. Dust collector (Journal No.550: Jul./2002): TENPES (Thermal and Nuclear Engineering Society of Japan)
4. Waste treatment and effective use (Journal No.556: Jan./2003): TENPES (Thermal and Nuclear Engineering Society of Japan)
5. Features and commissioning experience of dry clinker handling system (Journal No.559: Apr./2003): TENPES (Thermal and Nuclear Engineering Society of Japan)
6. Dust collection technology , ash handling and effective utilization technology of coal ash (Journal No.445: Oct./1993): TENPES (Thermal and Nuclear Engineering Society of Japan)
7. The outline—boiler (Journal No.583: Apr./2006): TENPES (Thermal and Nuclear Engineering Society of Japan)
8. Boiler ancillary facility (Journal No.587: Aug./2005): TENPES (Thermal and Nuclear Engineering Society of Japan)
9. Management of discharge, wastewater and waste oil for thermal power plant (Journal No.609: June/2007): TENPES (Thermal and Nuclear Engineering Society of Japan)
10. Utilization of Coal Combustion Ash by Electrostatic Separation and Water-permeable Concrete Pavement: Kobe Steel Engineering Reports/Vol. 53 No. 2（Sep./2003）