DEVELOPMENT OF AN ADVANCED OFF-GAS SCRUBBER FOR AN INCINERATING MELTER

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ABSTRACT

In the Chiyoda R&D center, the pilot plant of a Multi-Purpose Incinerating Melter has been tested in these two years.

This system can treat a wide variety of waste; combustibles and noncombustibles, and convert these into glass-like stable solids.

The incinerating melter is a partly rotating rotary-kiln-type furnace where the wastes are burned, molten and vitrified.

The off-gas scrubber is a wholly integrated system that uses the jet-bubbling technology developed by Chiyoda. The efficiency of the system is excessively beyond the level of conventional scrubbers.

INTRODUCTION

The Multi-Purpose Incinerating Melter System is being developed with the aim of being able to treat a large variety of wastes, combustibles and noncombustibles. These wastes are burned and then vitrified directly. So the total volume of the wastes are reduced ultimately.

The incinerating melter is a partially rotating rotary-kiln type furnace(1). The oscillating motion and a sufficient retention time enable the completion of the chemical reaction between molten components of the wastes.

The off-gas treatment system is a specially designed wet scrubber. The hot off-gas at about 1000°C, is directly injected into the scrubber across the special gas injection device. The system is highly integrated and treats gases derived from the incineration of a large variety of wastes.

This paper mainly describes the pilot test results of the off-gas scrubber.

OFF-GAS SCRUBBER

The off-gas scrubber is a high-efficiency wet scrubbing system.

As illustrated in Fig. 1, two jet-bubbling scrubbers and a post-scrubbing column are integrated into a single vessel.

The first jet-bubbling scrubber functions to cool down the hot gas that leaves the secondary chamber at approximately 1000°C and remove the particulates, sulfur oxides, hydrogen chloride and vapor-state radionuclei from the gas.

The jet-bubbling technology was originally developed as a FGD (Flue Gas Desulfurization) technology and its excellent performance has been proved by several commercial plants (2).

When the gas passes through the openings on the inner pipe, it generates a jet-bubbling layer (froth) where the liquid is violently motioned by the gas. The gas is fully contacted with the liquid, and then the soluble and insoluble impurities in the gas move into the liquid.

Figure 2 shows that the jet-bubbling mechanism is highly effective on the removal of the sub-micron particulate also, which could never be removed by conventional scrubber systems. The reason why the jet-bubbling mechanism has excellent dust removal covering from under-micron and sub-micron to over-micron particulates, is that its dust removal mechanism is not only by an inertial collision of the gas with the liquid at the sparging area but also by a diffusion and centrifugal collision of the particulates at the surface of up-flowing bubbles.

The second jet-bubbling scrubber functions for further removal of the particulates from the gas.

The mechanism is principally the same as the first jet-bubbling scrubber. The only difference between the first and second jet-bubbling scrubber is that the gas is sparged into a pipe through the openings from the outer side of the pipe in the second scrubber.

The post-scrubbing column is located above the second scrubber. This is a high efficiency packed column. The gas is finally purified in the column by its own condensate which is derived from its cooling to a temperature of about 50°C. The gas is passed through a wire mesh demister at the top section of the column to remove mist carryover.

Pilot Test Result

More than 50 runs of experiments have been conducted in these two years.

Many kinds of simulated wastes are crushed into 50 to 100 mm pieces, packed into a carton box, and then fed to the incinerator.

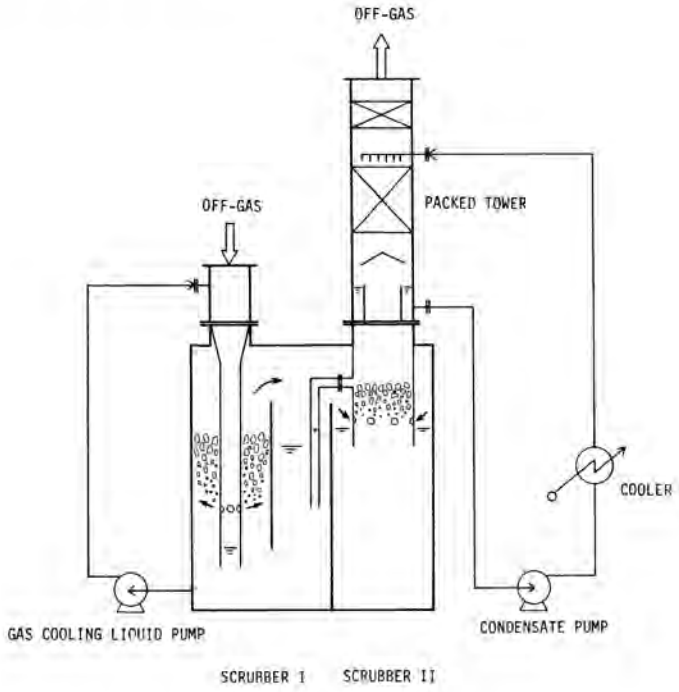


Fig. 1. Off-Gas Scrubber.

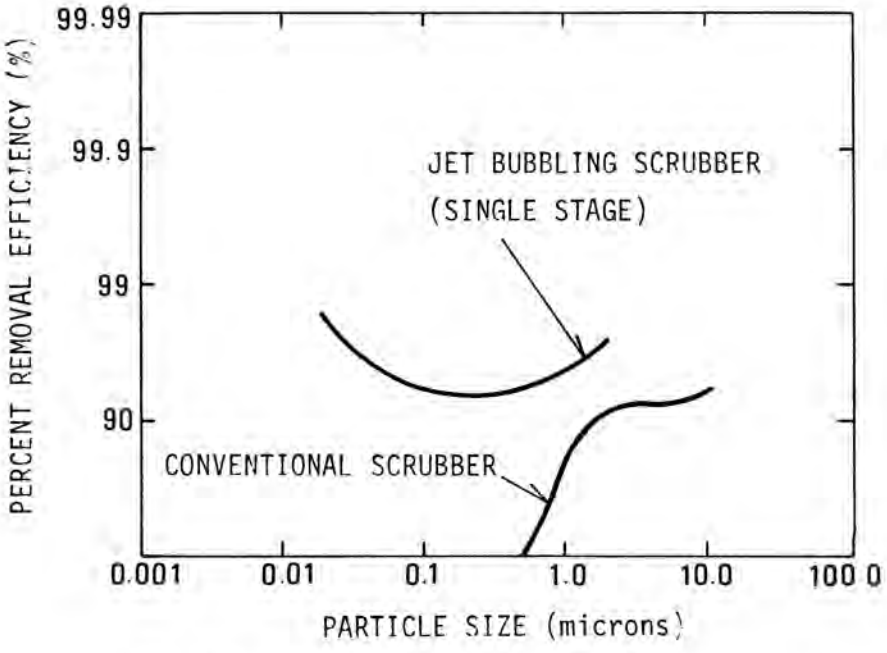


Fig. 2. Overall Particulate Removal Efficiency Curves.

- Coal Fired Boiler Data by Central Research Institute of Electric Power Industry, Japan -

Table I shows an example of the composition of the simulated wastes. The test number 1-6 are correspondent to:

1. as combustibles (wood, cloth, polyethylene, papers, cardboard)

2. as flame-retardants (rubber boots, rubber gloves, rubber gauntlets, rubber tube, polyvinyl chloride, helmet, polystylene, safety shoes)

3. as flame-retardants (spent resin)

4. as non-combustibles (glass, concrete, asbestos, gypsum board, rock wool, silicate board, cables, bolt and nut, thin metal plate, pipe)

5. as a mixture of 2 and 4

6. as a mixture of 1, 2 and 4

Table II shows the physical properties of the solidified products in each test.

All of the solidified products are vitrified and show excellent physical properties as a result of the oscillating motion and a sufficient retention time of the molten material at the incinerating melter.

Table III shows the test results of the scrubber system. The scrubber system with a diameter of 1,200 mmϕ treats the off-gas of 300 Nm^3/h at 1000°C successfully. The DF of Cesium from the incinerator to the outlet of the off-gas scrubber was around 10^3 when Cesium was added to the simulated wastes as a chemical tracer. So the DF of 10^6 would be expected from the incinerator to an HEPA filter.

HOT TEST PROGRAM

Chiyoda is now planning to carry out a hot test supported in part by a grant in aid for development of radioactive waste management from the Ministry of International Trade and Industry in Japan.

The hot test plant has a full system as an incinerating melter except the pre-treatment facilities of the wastes.

The throughput will be about 10 kg/hr, that is equivalent to 50% of the pilot plant. Wastes in a small carton box are fed into the incinerating melter and the molten material is discharged into a receiver.

TABLE I

Example of Simulated Wastes (% by Weight)

Classification	Simulated Wastes	Test Number					
		1	2	3	4	5	6
Combustibles	Paper	10	-	-	-	-	9
	Cloth	25	-	-	-	-	8
	Wood	50	-	-	-	-	7
	Polyethylene	15	-	-	-	-	1
Flame-retardants	Rubber	-	66	-	-	30	13
	Polyvinyl chloride	-	7	-	-	16	12
	Charcoal	-	27	-	-	4	-
	Resin	-	-	100	-	-	-
Non-combustibles	Glass	-	-	-	19	7	9
	Concrete	-	-	-	36	7	18
	Asbestos	-	-	-	21	7	10
	Gypsum	-	-	-	13	7	7
	Silicate	-	-	-	7	7	3
	Cable	-	-	-	1	-	1
	Metal	-	-	-	3	15	2

TABLE II

Example of Physical Properties of the Solidified Products

Test Number	1	2	3	4	5	6
Operating Temperature (°C) of the Incinerating Melter	1,100	1,300	1,300	1,550	1,300	1,300
Solidified Products						
- Composition (wt%)						
SiO_2	50.7	49.8	56.5	48.8	44.7	45.1
Al_2O_3	14.7	16.2	16.0	21.4	10.5	16.6
CaO	N.A.	N.A.	N.A.	15.3	N.A	20.0
MgO	N.A.	N.A.	N.A.	4.7	N.A.	3.6
Fe_2O_3	N.A.	N.A.	N.A.	7.0	22.6	7.6
Na_2O	11.2	7.7	8.7	2.4	4.4	3.9
Others	N.A.	N.A.	N.A.	0.4	N.A.	3.2
- Apparent Specific Gravity (-)	2.4	2.4	2.4	2.8	3.0	2.9
- Porosity (%)	N.A.	N.A.	N.A.	0.2	0.6	0.4
- Na Leacheability (g/cm^2-day)	$1.5x10^{-5}$	$1.3x10^{-5}$	$6.8x10^{-6}$	$1.0x10^{-5}$	$3.6x10^{-5}$	$1.4x10^{-5}$
- Crushing Strength (kg/cm^2)	N.A.	2,400	N.A.	N.A.	2,800	N.A.

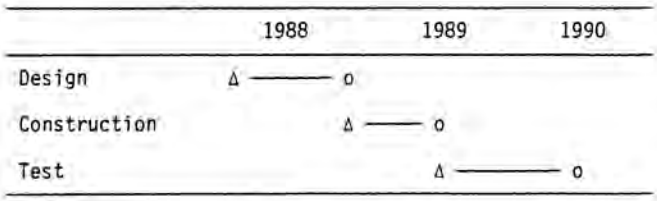
N.A. : Not analyzed.

TABLE III

Test Results of the Scrubber System

Type of Simulated Wastes	Operating Temperature of the Incinerating Melter (°C)	Feed Rate of the Simulated Wastes (kg/h)	Off-gas Temperature @ the Scrubber Inlet (°C)	Dry Gas Flow Rate @ the Scrubber Inlet (Nm^3-d/h)	Moisture Content @ the Scrubber Inlet (%)	SO_x @ the Scrubber		NO_x @ the Scrubber		HCl @ the Scrubber	
						Inlet (ppm)	Outlet (ppm)	Inlet (ppm)	Outlet (ppm)	Inlet (ppm)	Outlet (ppm)
Comoustibles	900 - 1,300	5 - 10	950	310	12	N.D.	N.D.	400	200	-	-
Flame Retardants (Rubber, etc.)	1,100 - 1,300	10 - 12	900 - 960	360 - 420	11 - 13	30 - 190	N.D.	150 - 280	100 - 250	300	9
Flame-Retardants (Spent Resin)	1,100 - 1,300	5 - 18	750 - 1,000	290 - 400	11 - 17	60 - 150	N.D.	200 - 450	100 - 250	-	-
Non-combustibles	1,550	15	960	310	13	10	N.D.	400	250	-	-
Mixture of Flame-retardants and Non-combustibles	1,300	15 - 20	860 - 1,100	290 - 330	13 - 17	40 - 130	N.D.	90 - 400	70 - 250	-	-
Mixture of Combustibles, Flame-retardants, and Non-combustibles	1,300	10 - 30	860 - 1,020	300 - 340	13 - 22	21	N.D.	400	200	160	5

The hot test will be conducted in 1989 and 1990 by the use of radio isotopes, etc. The master schedule is listed below.



CONCLUSIONS

The pilot test confirmed that the multi-purpose incinerating melter and its off-gas scrubbing system are compact and simple, able to achieve ultimate volume reduction with a wide variety of wastes, to convert wastes into a stable and rigid vitreous product and to clean the gaseous effluent.

ACKNOWLEDGEMENT

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