Pyrolysis And Melting System

Susumu Uno

TAKUMA Co., LTD.
2-2-33, Kinrakuji-cho, Amagasaki, Hyogo, Japan

ABSTRACT

In 1995 we licensed pyrolysis gas melting technology of indirect heating type (using kiln) from Siemens AG, and built its demonstration facility in 1998 at Clean-Park-East of Fukuoka City to demonstrate the technology for municipal solid waste (MSW). In 1997 we were awarded an order frum Kanemura Co., Ltd. to build a pyrolysis gas melting and power generation plant, specifically for treating residue from car shredder. The latter was launched in 1998, and is currently in commercial operation.

The operation of these plants have proven the following facts.

(1) The system is capable for performing a stable operation with a wide variety of waste.

(2) Pyrolysis is achieved steadily regardless of the variation in the quality of waste.

(3) The system can be operated under low excess air ratio (1.2~1.3).

(4) The concentration of dioxins at the furnace outlet is 0.062ng-TEQ/m^3_N, and 0.002ng-TEQ/m^3_N at the stack.(the value is corrected to dryO_2 12%)

(5) The purity of recovered metals exceeds 90%.

INTRODUCTION

Lately, MSW incinerators face public demands for reduction of dioxins emission, high-efficiency thermal recovery and stabilization through melting processes. Pyrolysis gas melting system is drawing attention as the next-generation waste treatment technology that meets such demands. Kiln type and fluidized-bed type are the two major varieties of this system.

In 1995 we licensed from Siemens AG their Indirect Heating (Kiln type) Pyrolysis Gas Melting Technology (hereafter called the "Technology"). A demonstration plant (hereafter called FDP) was built in 1998 at the Clean-Park-East of Fukuoka City for the purpose of obtaining the Technical Evaluation approved as an "Non-Standard Facility." and to demonstrate the Technology. Separately, we were awarded an order from Kanemura Co., Ltd. in 1997 to build a pyrolysis gas melting and power generating plant for the disposal of automobile shredder residue (hereafter called ASR). The latter plant (hereafter called KP) has been in commercial operation since its taking-over in 1998.

The following article describes the characteristics of the Technology we defined through the operation of the two plants.

PLANT OUTLINE

Fig.1 shows the system flow. The sheared waste (smaller than 150mm in size) fed to the pyrolysis drum (hereafter called the drum) is heated indirectly up to approx.500 by heating pipes installed inside.

It is pyrolized in approximately an hour, turning into pyrolysis gas and pyrolysis residue. The gas is sent directly to the high-temperature combustion chamber, while the residue is cooled down on vibration conveyor and moves to the separating unit consisting of various separators. Valuables such as iron and aluminum are recovered, and the remainder is crushed and stored as carbon residue. Carbon residue is sent back to the high-temperature combustion chamber pneumatically.

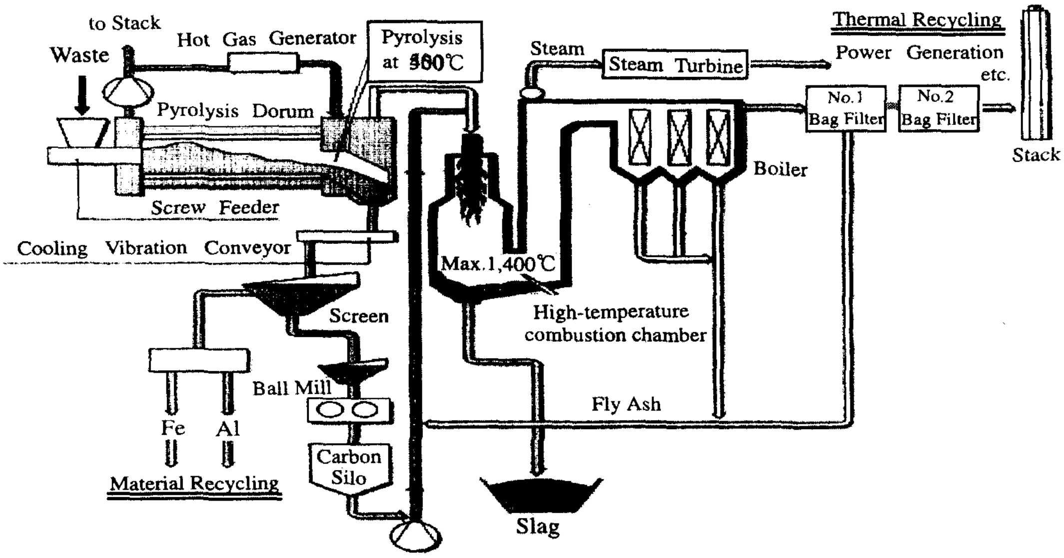

Fig.1 System flow

At high-temperature combustion chamber, pyrolysis gas, carbon residue and dust collected by gas cooling unit and flue gas treatment facilities are fed from the top, and they are burned and melted on the inside surface.

The furnace inside is controlled so that the temperature at the slag hole maintains 1280 . The molten slag falls from the tap hole into the submerged conveyor, and is discharged as water-quenched slag.

The exhaust gas from the high-temperature combustion chamber is cooled down at water spray tower. After that, two bag filters are located in a line. Fly ash is separated by No.1 bag filter, and then toxic gases such as HCl and SOx are removed by slaked lime injection at No.2 bag filter.

Dioxins are controlled by high-temperature combustion at the chamber, sufficient residence time, resulting concentration is less than 0.1ng-TEQ/$m^3{}_N$ at the stack.

Main specification of KP and FDP is shown in Table 1 and design characteristics of waste in Table 2.

< Table 1 Plant specification >

	KP	FDP
Treated waste	Automobile shredder residue	Municipal solid waste
Capacity	90 ton/day	20 ton/day
Main facility		
Boiler	Waste heat boiler (4.6MPa sat.) Steam generation 20ton/h Turbine Generator 2,000 kW	Waste heat boiler (4.6MPa sat.) Steam generation 1.5 ton/h
Flue gas treatment	ESP, Bag filter Slaked lime pneumatic conveyor Activated carbon pneumatic conveyor	No.1, No.2 Bag filters Slaked lime pneumatic conveyor Activated carbon pneumatic conveyor

< Table 2 Design characteristics of waste >

		KP		FDP		
		Ave.	Range	Ave.	Max.	Min.
Combustible	%	62.5	-	40	52	29
Ash	%	30	max 40	12	11	12
Moisture	%	7.5	max 10	48	37	59
Low calorific value	kJ/kg	18,844	16,750 to 20,938	7,956	10,469	5,443

OPERATION REVIEW

This section reports the results we obtained from above two plants, namely, the stability of indirect-heating pyrolysis, stable combustion at a low excess air ratio, control of dioxins emission.

Pyrolysis Reaction

One of the characteristics of the drum is the fact that the reaction is not affected by changes in quality of waste fed from the screw feeder, since the waste remains in the drum for about an hour while the pyrolysis reaction taking place.

Fig.2 displays the change in temperature of the pyrolysis residue at various points inside the drum based on elapsed time. As seen, variation is minimal, and it is indicating the stability of pyrolysis reaction. Fig.3 shows pyrolysis residue temperature in the drum. It is 20°C at the drum inlet, and rises to 500°C at the outlet, forming a gentle upward curve. This indicates that the pyrolysis reaction takes place gradually. We also included temperature curve at 60% load, and also with 20% water added. The change in load rate variation only moves the pyrolysis completion point of 450°C, maintaining the temperature at the outlet at a similar level. This proves the stability of pyrolysis can be obtained even under varied loads.

The drum is heated by the heating gas, and is controlled so that the temperature at the inlet is 530°C, and 300°C at the outlet. After leaving the drum outlet, the heating gas goes into the hot gas generator where it is heated to 530°C by kerosene burner, and is fed back to the drum. The circulating gas volume is controlled so that its temperature at the drum outlet is 300°C. Thus, the temperature of heating gas at the inlet and outlet of the drum are maintained at constant levels to enable a stable pyrolysis reaction.

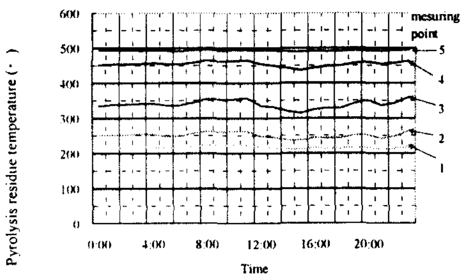

Fig.2 Pyrolysis residue temperature in pyrolysis drum(FDP)

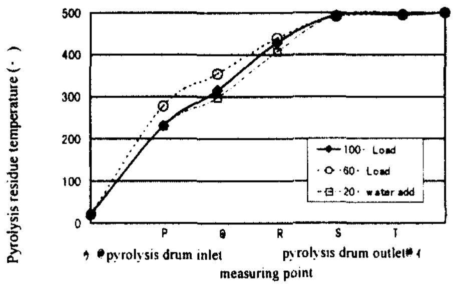

Fig.3 Pyrolysis residue temperature in pyrolysis drum(FDP)

Pyrolysis process produces pyrolysis gas and pyrolysis residue. Their constituents and ratio depend on the chemical composition of the waste. Moisture goes entirely to the gas, and ash to the residue. The inflammables tend to move toward pyrolysis gas when the waste contains more plastics, and move to the residue in case of kitchen wastes.

The ratio of pyrolysis gas versus residue from the waste was 6:4 with KP, and 7:3 with FDP. Table 3 lists an example of pyrolysis gas analysis ,and Table 4 lists carbon residue analysis.

< Table 3 Pyrolysis gas analysis >

Content	Unit	Analysis data	
		KP	FDP
CO_2	%-dry	30.8	23.5
CO	%-dry	3.7	15.2
H_2	%-dry	14.5	3.3
CH_4	%-dry	5.2	7.3
C_2H_6	%-dry	2.8	-
C_2H_4	%-dry	2.2	3.2
C_3H_8	%-dry	1.4	0.5
C_3H_6	%-dry	3.8	2.3
Tar	kg/m^{3}dry	2.2	1.1
Low calorific value	kJ /m^3_N-wet	18,593	4,920

< Table 4 Carbon residue analysis >

Content	Unit	Analysis data	
		KP	FDP
Ash	%-dry	65.4	39.6
Volatile	%-dry	12.6	16.4
Fixed carbon	%-dry	21.9	44.1
Apparent specific gravity	t/m^3	0.53	0.52
Average particle size	· m	40	20
Low calorific value	kJ/kg-dry	9,548	16,361

Low Excess air Ratio

The Technology enables complete combustion in spite of low excess air ratio by means of constant pyrolysis gas generation with one-hour residence time, and by means of the carbon residue injection at a steady rate. The combustion air is injected at three stages to avoid local temperature rising, and the secondary and tertiary air volumes control the oxygen concentration at the furnace outlet.

Fig.4 illustrates the relationship of excess air ratio and CO content at FDP. The excess air ratio is to be kept at 1.2 to 1.3 in order to keep the CO content at the low level. Fig.5 shows the relationship between the oxygen and CO content of exhaust gas at combustion chamber at FDP. The CO content is below 1ppm, and a stable combustion is accomplished at the excess air ratio of 1.2 to 1.3.

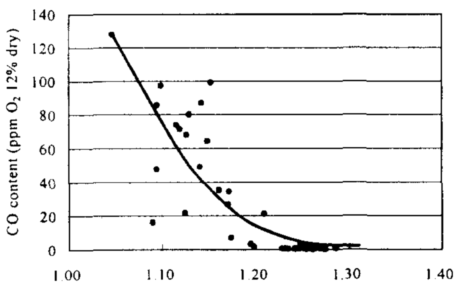

Fig.4 Relation between CO content and excess air ratio(FDP)

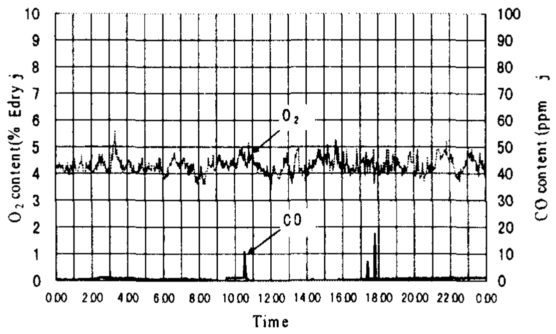

Fig.5 O_2· CO content of flue gas(FDP)

Dioxins

The high-temperature combustion chamber enables low dioxins generation with its complete combustion by means of stable combustion maintaining low excess air ratio. Also, activated carbon is injected into upstream of No.1 bag filter for dioxins removal. Table 5 lists the composition of the exhaust gas at the stack outlet of FDP, and its dioxins mass-balance is illustrated in Fig.6. The dioxins concentration at the high- temperature combustion chamber outlet is 0.062ng-TEQ/$m^3{}_N$, and 0.002ng-TEQ/$m^3{}_N$ at the stack. It means the dioxins emission from the facility is 0.17μg-TEQ/waste-ton. Without activated carbon injection, dioxins concentration at the stack is 0.026ng-TEQ/$m^3{}_N$. In case of KP, The dioxins concentration at the high-temperature combustion chamber outlet is 3.0 ng-TEQ/$m^3{}_N$, and 0.02ng-TEQ/$m^3{}_N$ at the stack with activated carbon injection.

< Table 5 Flue gas content analysis >

Content	Unit	FDP
CO	ppm-$O_2$12%	<1
NOx	ppm-$O_2$12%	90
HCl	ppm-$O_2$12%	120
SOx	ppm-$O_2$12%	21
Dust	g/$m^3{}_N$-$O_2$12%	0.045

(with activated carbon injection)

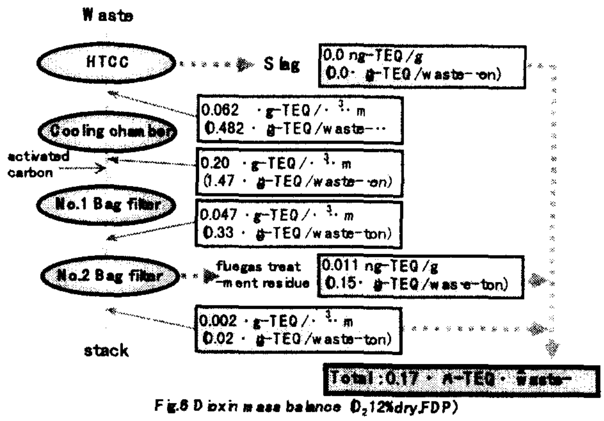

Fig.6 Dioxin mass balance ($O_2$12%dry,FDP)

Material Recycling

The recovered metals are clean without oxidation, as the pyrolysis occurs in the state where there is almost no air. We checked the purity of recovered iron and aluminum, and found iron purity is 96% and aluminum purity is 91%. Also, since pyrolysis is finished at less than 500°C, aluminum does not melt.

In KP, 10% is recovered from ASR as iron, and 20% is recovered as slag. There, slag is ground and is reused as aggregate for concrete.

Thermal Recycling

When the operation result of FDP is converted to a facility of actual, the exhaust gas volume is reduced by about 30% compared with the existing plants, and improve the boiler efficiency by about 3%. It means that the use of pyrolysis gas melting system enables higher thermal recovery compared with the conventional methods.

CONCLUSION

We have demonstrated the superiority of the next-generation waste treatment facility using pyrolysis at FDP in its stable high-temperature combustion melting and thermal recovery, as well as low emission and better recycling. The facility at KP has also proven its practical merits as the first commercially operated pyrolysis gas melting furnace with power generation. Not reported here, we have got valuable data through the operation of these two plants, such as thermal transmission characteristics of the drum, amount of heat required for pyrolysis, the durability of heating pipes and heat load of the high-temperature combustion chamber, and so on.

We are convinced that the operation of these two plants amply testifies that the Technology is the waste treatment method suitable for the recycling-oriented community of the future.

KP is performing operation for the present(Sept. 2001) about 20,000 hours.
Pyrolysis Demonstration Plant (FDP) was operated as a joint effort with the City of Fukuoka, and we received the Technical Evaluation from the Waste Research Foundation on August 30, 1999.

At closing, we wish to express our sincere appreciation for those who extended their valuable assistance in this undertaking.

REFERENCES

1)Y.Kawai, A.Taguchi,"Pyrolysis Gas Melting System", proceeding of ICIPEC Seoul, Korea, pp.127-137(2000)
2)K.Nakatani, "Pyrolysis Gas Melting System", proceeding of the 10th Pacific Basin Conference on Hazardous Waste(2001 PBC in Okayama),pp.115-120