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Oxy-fuel Combustion of Sewage Sludge using a Circulating Fluidized Bed

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INTRODUCTION

Fossil fuel combustion generates large amount of green house gas and it was considered major emission source causing global warming. For reducing green house gas, renewable energy resources have been emerged as an alternative energy. Among those resources, waste has been considered major resource as one of renewable energy, but it has been not utilized sufficiently. In Korea, there are lots of efforts to utilize sewage sludge as one of renewable energy resources due to waste to energy project of government. In this paper, sewage sludge was utilized as a fuel in order to recover heat energy source with CO_2 reduction using oxy-fuel combustion in 30KWth circulating fluidized bed (CFB) pilot plant.

EXPERIMENT AND METHOD

Dried and pelletized sewage sludge is used as a fuel that is transported from in sewage treatment facilities in Korea, and diameter of it is 10 ~ 35mm, density is 0.84 g/cm^3. For applying fuel, proximate analysis, element analysis, calorific value analysis comparing with coal were conducted. The results of properties of sewage sludge are shown under <Table 1>.

Table 1. Properties of sewage sludge and coal

Analysis		Sewage sludge	Coal	Analysis		Sewage sludge	Coal
Proximate analysis (wt.%)	Moisture	7.32	9.31	Element analysis (wt.%)	Carbon	28.14	73.08
	Volatile	45.11	27.91		Hydrogen	4.74	4.52
	Fixed carbon	12.25	51.26		Nitrogen	4.43	1.89
	Ash	35.04	11.52		Oxygen	23.9	19.93
Higher Heating Value (kcal/kg)		3,010	5,970		Sulfur	0.43	0.58

The schematic of CFB reactor is shown under <Fig. 1>. The reactor consists of gas injection unit, combustion zone, feeder, heat recovery unit, air pollution control devices. Fuel input rate is estimated to 13 kg/hr using properties of sewage sludge results. For maintaining CFB, a quantity of gas injects under the combustion zone. After combustion zone preheated at 800 ^oC, fuels are started to feed to reactor.

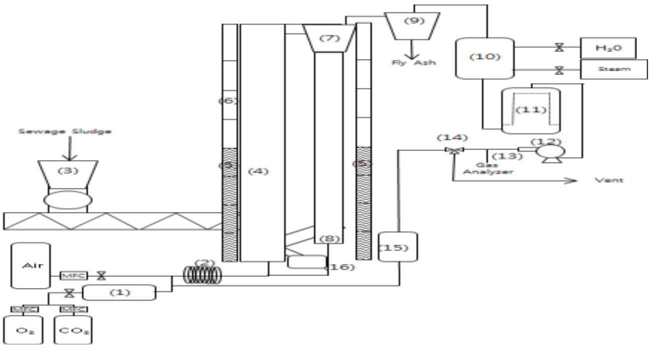

Fig. 1. Schematic diagram of circulating fluidized bed combustor; (1) gas chamber (2) pre-heater (3) fuel feeder (4) combustor(riser) (5) heater (6) insulation (7) 1st cyclone (8) loop-seal (9) 2nd cyclone (10) steam generator (11) bag filter (12) I.D, fan (13) gas sampling point (14) 3way valve (15) flue gas storage tank (16) Bottom ash collector

Combustion efficiency is calculated using combustible component in fly ash, bottom ash. The composition of flue gas is simultaneously measured using gas analyzer (Kinsco technology, Hymeth Plus Model, Republic of Korea).

RESULTS AND DISCUSSION

When U/Umf is 8, it confirmed to observe to pressure and temperature gradients for identifying CFB as shown in <Fig. 2, 3>. Pressure gradients increase in proportion to volume of input gas per moles. In case oxygen concentration increase, temperature gradients generally increase. But heat loss increases because excess oxygen leads to cooling combustion.

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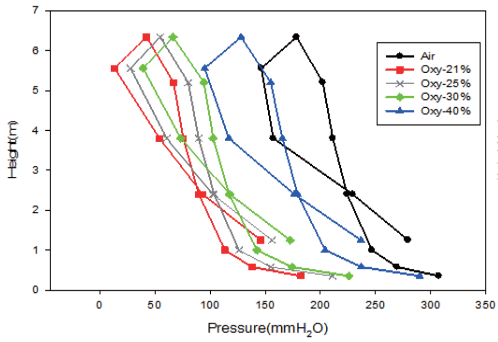

Fig 2. Pressure gradients at U/Umf : 8

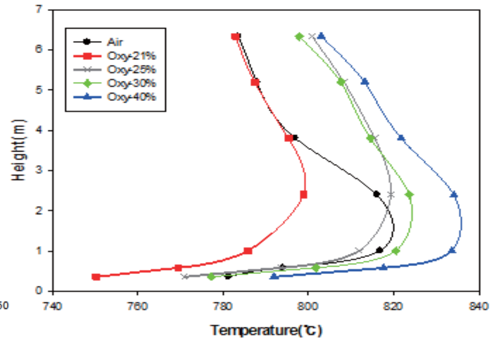

Fig 3. Temperature gradients at U/Umf : 8

Combustible components of bottom ash are less 1%. So calculated combustion efficiency is up to 99% the reason why particles are properly recirculated and residence time is enough. In case of fly ash, combustible components are 2 ~ 4.5 % in shown in <Table 2>

Table 2. The results of combustion efficiency

Condition of combustion		Air	Oxy-21%	Oxy-25%	Oxy-30%	Oxy-40%
Combustion efficiency (%)	Fly ash	95.47	92.15	96.15	95.26	94.44
	Bottom ahs	99.13	99.02	99.39	98.88	99.09

Air condition and Oxy-21% are applied to an appropriate excess air ratio. Concentration of carbon monoxide is kept low except for Oxy 21%. And combustion maintain stable at all conditions. NOx emission is 47 ~ 73 ppm at air and oxy condition. And NOx emission of oxy-21~25% is lower than air condition. SOx emission of air condition is approximately 550 ppm. In Oxy-25%, SOx emission is the highest. If oxygen concentration increases, SOx emission is proportional to decrease. In Oxy-40%, SOx emission is the lowest.

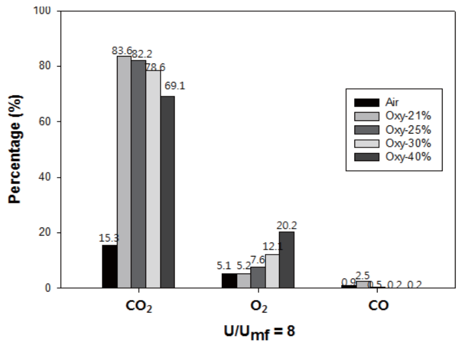

Fig 4. Flue gas components at U/Umf : 8

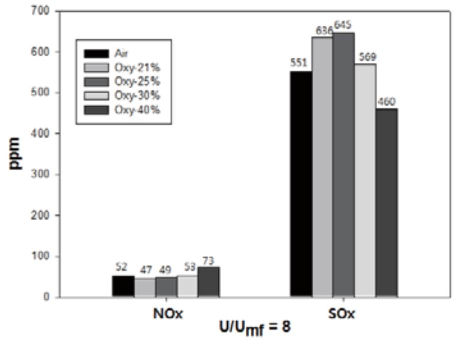

Fig 5. NOx & SOx emsission at U/Umf : 8

CONCLUSIONS

The oxygen concentration increased, excess air ratio increased. Since it is caused by cooling combustion in the top of combustion zone. Pressure gradients increase in proportion to volume of input gas per moles. Therefore, Oxy-21~25% is suitable to sludge oxy-fuel combustion. The recirculation of solid has been made properly, and moisture contents a little increase in oxy-fuel combustion. Combustion efficiency is the highest at Oxy-25%. NOx and SOx emission is affected by temperature. In case of cooling combustion, NOx emissions are increased, SOx emissions are decreased.

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