Ash Fusibility Behavior of Coal and Combustible Solid Waste Blends in Thermal System

Nayeon Lee[1], Bongjin Jung[1], Rak-Hyun Song[2]

***Abstract*—** At the melting technology, free flow of molten ashes from taphole is very important in the successful operation of solid wastes and fuels utilization equipments such as direct melting furnace and the slagging gasifier et al. Melting behavior of coal blended with combustible solid waste fuel can be characterized by several temperatures relating to stages of deformation of cone or cylindrical-shaped ash samples on heating by analytical instrument to evaluate the suitability of easy tapping of molten ashes for the use of their blending fuel in the above devices. This test is generally based on the use of shrinkage levels for an ash sample during heating. Viscosity of any molten ash through molten temperature range is also useful for characterization of melting behavior of sample. The cone or cylindrical-shaped test for measurement of ash fusibility temperature using heating microscope may give different results in measurement of melting temperature for some solid fuel ash samples without the information of viscosity data of molten ones. Even though without the viscosity results of solid fuel ashes, sometimes quick test results by heating microscope may be a good guidance to estimate the suitability of easy slag tapping behavior of sample. So several ashes of coal or combustible solid waste samples having their different blending ratios were used in this study to find the different behavior of four melting temperatures (IDT, ST, HT, FT), that is, decrease or increase of melting temperature depending on blending ratio of samples.

***Keywords*—** Coal, Solid waste, Ash, Heating microscope.

I. Introduction

The rising price of fossil fuels worldwide and a policy of national waste-energy and biomass in order to reduce greenhouse gas emissions and the corresponding need for renewable energy, such as Renewable portfolio standard(RPS) are being actively pursued. In addition, the situation in the industry and the need to do related companies respond effectively to the RPS mandates of renewable energy supply system emerged. In the case of domestic coal-fired power plants, but currently uses coal as a single fuel, the need to use a certain amount to dual fuel waste and biomass in existing fossil fuel to a renewable energy future has emerged RPS achieved. However, in the case of Korea’s thermal conversion process because it is the coal situation and experience of dual fuel waste and biomass into a fluidized bed combustion scarce etc., properties of dual fuel is fuel that is used to continually take place in facilities ash agglomeration operation, including failure that may occur due to differences such as the need to cope with previously identified. In this study ashe of coal or combustible solid wast e samples having their different blending ratios were used in thi s study to find the different behavior of four melting temperatur es (IDT, ST, HT, FT), that is, decrease or increase of melting t emperature depending on blending ratio of samples.

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II. Melting Behaviors of Inorganic Matters of Coal

Inorganic matters of coal can be divided mainly to clays, silicates, carbonates, and sulfides compounds. Among such inorganic matters, clay compound accounts for about 60-70%, silicates compound about 20-30%, and other carbonates and sulfides compounds are also contained. When clay compounds, whose major component is Kaolinite, are heated up to 500℃, chemically combined moisture starts to be separated and go through a conversion process that forms mullite or free silica. The separated free silica functions as a frame worker that forms aluminosilicates copolymer in Na, K, Ca, and Fe oxide. Pyrite is a major component of sulfide compounds, and plays the key role in reducing the melting point in most types of slag. When carbonate compounds, whose major components are Calcite and dolomite, are heated up to 800℃, they generate CO_2 with calcium oxide or magnesium oxide left. Such calcium oxide or magnesium oxide has a high melting point, but functions as a flux since they go through a prompt reaction with other compounds that are already in a liquid phase at a high temperature upon coal combustion or gasification.

Such inorganic matters generate ash as an unburnt residue after going through a conversion process during combustion and gasification, and such elements as SiO_2, Al_2O_3 and TiO_2 in an ash composition are classified as acidic oxide while Fe_2O_3, CaO, MgO, Na_2O, and K_2O are as basic oxide. Ash may be classified to bituminous type ash and lignitic type ash depending on the content of iron oxide. Bituminous type ash contains Fe_2O_3 more than CaO+MgO while lignitic type ash contains CaO+MgO more than Fe_2O_3. In general, high-rank coal is likely to be bituminous type ash while low-rank coal lignitic type ash. Hence, these may show different slag characteristics at a high temperature as the system is heated. Ash melting also results in such. problems as clinker formation in a fluidized bed reactor and slagging or fouling in a pulverized coal combustor, which are some of the major causes of reducing the process efficiency

III. Experiments

A Indonesia subbituminous coal and combustible solid waste(MSW) samples were selected for experiment. Proximate and ultimate analyses were carried out using ASTM standards to investigate the basic properties of the samples. Each sample was analyzed three times and then the average value of that was used for the information of samples. After the sample was dried during four hours at 105℃, it was pulverized to 100 mesh(150 μm). It was dried again at 105℃ during one hour for preparation of sample analysis. And Using the above samples, proximate analysis, ultimate analysis(LECO Thruspec, USA), Heating value(PARR 6300, USA), XRF(X-ray Flourescence Spectrometer, SRS3400 Bruker AXS, Germany), XRD(X-ray Diffractrometer, D8 Advanced, Bruker, Germany), Heating Microscope(Misura, Italy) etc. were measured. Ash samples from two samples were prepared by using the standard ASTM ashing procedure.

IV. Results And Discussions

Results of proximate and ultimate analyses of coal and solid waste samples used in this study is shown in Table 1. In the proximate analysis, coal showed about 38wt.% fixed carbon, 52wt.% volatile matter and 6wt.% ash but solid waste sample unlikely coal showed about 8wt.% fixed carbon, 80wt.% volatile matter and 12wt.% ash on the dry basis. Clorine contents of coal and solid waste were 0.01wt.% and 7.56wt.% as dry basis in the ultimate analysis, respectively. . In the Calorific value analysis, coal and solid waste showed nearly similar data which are about 5900~6500kal/kg.

Table 1 Physical Properties Of Coal And Solid Waste (Wt.%,Dry Basis)

composition	Coal	Solid Waste
Volatile Matter	55.62	80.07
Fixed Carbon	38.58	7.94
Ash	5.80	11.99
C	71.73	53.38
H	4.98	7.94
N	1.20	0.75
S	0.46	0.34
O(by diff.)	15.82	25.60
Cl	0.01	7.56
Calorific Value (HHV,kcal/kg)	6570	5904

Compositions of coal ash and solid waste ash in the viscosity measurement are shown in Table 2. Ten principal oxide constituents of ash can be divided into those that are acidic in the pyrochemical sense (SiO_2, Al_2O_3, P_2O_5, and TiO_2) and those that are basic (Fe_2O_3, CaO, MgO, K_2O, and Na_2O). The acidic oxide constituents are generally considered to produce high melting temperatures. Temperatures will be lowered proportionally by the relative amounts of basic oxides available in the ash for reaction.

Table 2 Ash Compositions Of Coal And Solid Waste Samples (Wt.%)

composition	Coal	Solid Waste
SiO2	30.14	19.96
Al2O3	17.01	11.17
TiO2	0.77	3.47
P2O5	0.18	4.15
Fe2O3	9.01	2.54
CaO	20.92	31.96
MgO	5.98	3.85
Na2O	4.64	5.48
K2O	1.07	2.35
SO3	9.45	4.27
B/A	0.87	1.19

Results of Heating Microscope analyses of coal and solid waste samples used in this study is shown in Figure 1. To analysis of ash fusion temperature, coal, solid waste and coal and waste blending ash to weight ratio 80%:20% were selected for experiment. Figure 2&3 show the Fusibility behavior of 80:20% blending sample at oxidizing atmosphere

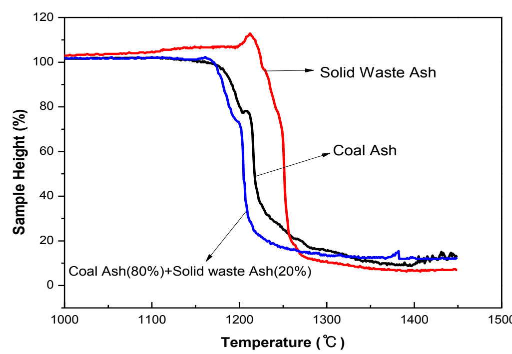

Fig. 1 Comparison of fusibility profile of various samples

Sample shapes					
Classification	Initial	IDT	ST	HT	FT
Temp	20	1176	1204	1207	1270
Sample Height	100	94.98	61.00	38.22	15.06
Remarks	IDT~FT : 1,176 ~1,270 (at oxidizing atmosphere)				

Fig. 2 Fusibility behavior of coal and solid waste 80:20% blending sample

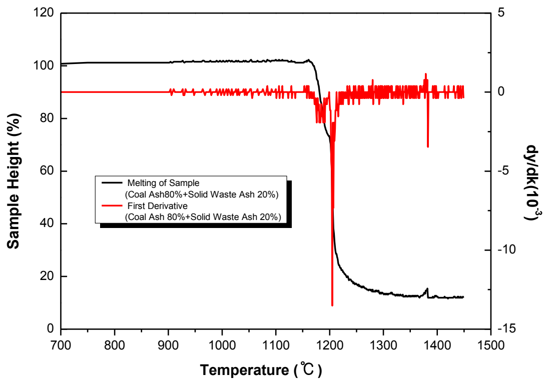

Fig. 3 Fusibility behavior diagram of coal and solid waste 80:20% blending sample

As a result of comparing the XRD data of the coal, combustible solid waste ash and coal and solid waste 80:20% blending samples it is shown in Figure 4. According to the XRD analysis of coal SiO_2, $CaSO_4$ were existed as main crystalline and major peak of Solid waste is Gehlenite($Ca_2Al_2SiO_7$). In the coal and solid waste blending sample, SiO_2, $CaSO_4$ were existed as main

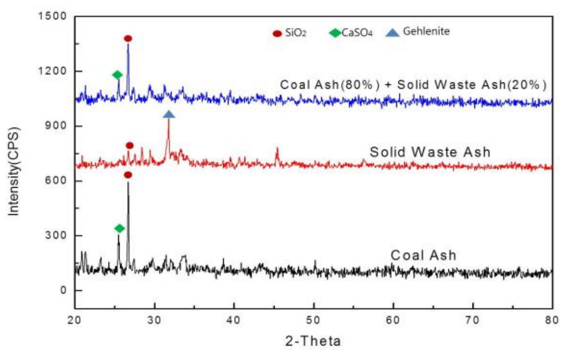

Fig. 4 Comparison of XRD pattern of various samples

V. Conclusions

Major components of coal and solid waste incineration ashes are different that in the coal case, SiO_2 is major and solid waste is CaO

The flow temperature of the coal ash and combustible waste ash but each 1310 ℃ and 1268 ℃, the flow temperature (FT) of the mixed sample is compared to the ash in the coal ash sample 1270 about 40 ℃ lower degree

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