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Combustion Observation of Co-firing with Bituminous and Sub-bituminous Coals in Oxy-fuel Condition

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1. Introduction

The application of blending coals with bituminous and sub-bituminous is being emphasized to overcome coal resources problem. Coal blending can be a promising technology in terms of coal supply security, coal cost and plant capacity goals. On the other hand, oxy-fuel combustion has several advantages including fuel flexibility and CCS (CO_2 Capture and Storage). The other advantage of coal blending and oxy-fuel combustion is that it can be applied to conventional pulverized coal power plant through a retrofit as well as a new pulverized coal power plant. Therefore, Co-combustion of coal blending under oxy-fuel combustion may be suggested as an alternative method to solve economic and environmental issues as well.

In order to apply coal blending technology to oxy-fuel combustion, the effect of coal rank, coal particle size and variations of oxidizing agent on the combustion characteristics including combustion behaviour, ignition temperature, reaction kinetics and activation energy of coal particles should be understood in detail. Some studies in terms of the coal blending or oxy-fuel combustion conditions considering these parameters have been conducted.[2-6] However, researches on the combustion characteristics of blended coals with bituminous and sub-bituminous under oxy-fuel combustion conditions are rare. In this study, two kinds of coals (Arthur and KPU), used in practical pulverized coal power plant, were selected to investigate the combustion characteristics of blended coals with bituminous and sub-bituminous under oxy-fuel combustion conditions. The effects of oxygen concentration and blending ratio on the combustion characteristics were experimentally investigated using a thermogravimetric analyzer (TGA). To investigate the effects of fuel and oxygen concentration on the excess heat, total oxygen concentration was defined as summations of fuel oxygen (ultimate analysis) and oxidizing oxygen (purge gases). Characteristic temperatures including ignition and burnout temperature were determined from TG and DTG curves.

2. Experimental Method and Conditions

One Australian coal, Arthur bituminous coal and one Indonesian coal, KPU sub-bituminous coal were selected for the experiments. The raw coal sample was crushed and pulverized firstly using a bench-scale mill in the laboratory and then sieved on the screen vibrator. The proximate and ultimate analyses of samples are summarized in Table 1. For blended coal, blending ratio was set to 100%, 75%, 50%, 25%, 0%, respectively, based on bituminous coal 100% content.

Temperature-programmed combustion tests were performed in a themogravimetric apparatus (TA Instrument SDTQ600). About 20 mg of each sample (45-75 μm) was heated at 10 K/min from ambient temperature up to 1173 K, with a flow rate of 100 mL/min for air and mixture of carbon dioxide and oxygen. The oxygen concentration was used varied in mixtures of O_2/N_2 (air) and O_2/CO_2 (oxy-fuel) in the range of 21% and 10%, 30%, 50%, respectively.

3. Effect of Coal Blending and Oxygen Concentration

Fig. 1 presents the effects of the oxidizing conditions on the thermal behaviors of the Arthur and KPU blends. The temperature at which the volatile starts to be released is shifted to early with the addition of KPU. The devolatilization was enhanced by the addition of sub-bituminous coal. Temperature drops were also evident for blended coals. In the Fig. 1(b), the temperature drop for K (KPU 100%) in around 630 K also was observed in A25 + K75, A50 + K50 and A75 + K25. However, the position of temperature drop was shifted to early stages. The temperature drop was not observed in Arthur of 100%. Moreover, in Fig. 1(c) and (d), the temperature drop was observed in all blending conditions including even Arthur 100% at high oxygen concentration. To investigate the effect of total oxygen concentration for fuel and oxidizing oxygen concentration on the heat flow distributions, the values of total oxygen concentration was defined as the value of summations of fuel oxygen (ultimate analysis) and oxidizing oxygen (purge gases). The ignition temperature of bituminous coal could be lower by blending with sub-bituminous coal. In addition, the effect of coal blending and oxygen concentration on combustion termination temperature was also discussed.

Table 1 The ultimate and proximate analysis of coal samples.

Coal	Proximate analysis (wt. %, air-dry)				Ultimate analysis (wt. %, dry)						HHV(kcal/kg, air-dry)
	M	VM	FC	Ash	C	H	O	N	S	Ash	
Arthur	0.15	35.96	41.07	22.82	70.2	5.09	5.87	1.71	0.97	16.16	6,615
KPU	11.3	45.27	34.85	8.59	66.6	5.77	18.86	1.19	0.07	7.5	5,418

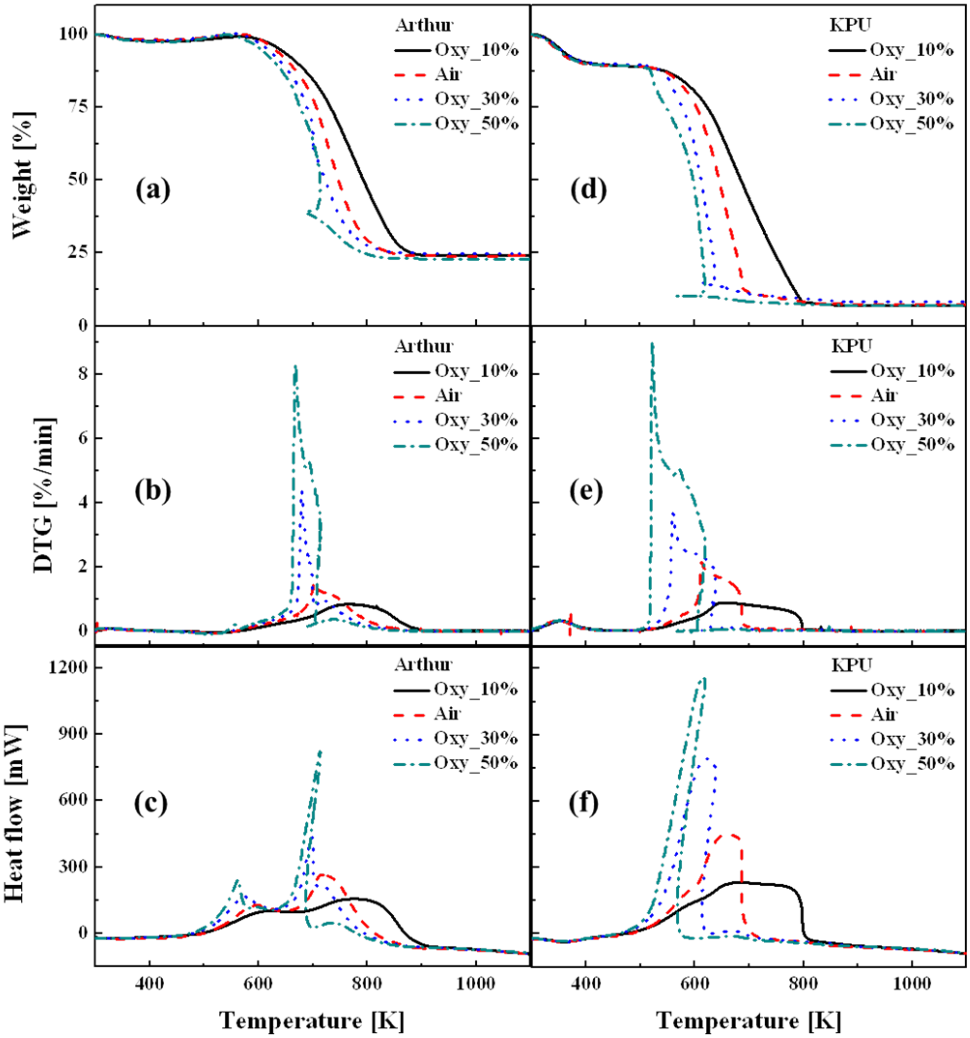

Fig. 1 TG, DTG and DSC curves for single coal with different atmosphere.