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Study on Synergy of Co-pyrolysis between Coal and Rice Straw

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***Abstract*—Pyrolysis of the mixture of Beisu coal and rice straw was studied with thermogravimetric analysis (TG). The results show that with the decrease of the mass ratio of Beishu coal in the mixture, the weight loss of the mixture of straw and Beishu coal increases gradually during pyrolysis. There are two main thermogravimetric peaks in the DTG curve of the mixture between 200~550 oC, which are between the thermogravimetric regions of straw and Beishu coal pyrolysis alone. The co-pyrolysis process of the mixture of Beishu coal and straw with a mass ratio of 3:1 was compared with that of the mixture at different heating rates. It was concluded that the increase of heating rate would result in the increase of temperature required for the pyrolysis reaction of the mixture and the increase of residual pyrolysis products. There is a synergistic effect between the coal and straw in the process of CO pyrolysis.**

Keywords—Coal, Straw, Co-pyrolysis, TG

I. Introduction

Coal resource is abundant, and accounts for over 70% of the disposable energy structure and consumption structure in China. The direct combustion of coal will produce a large amount of sulfur dioxide gas, nitrogen oxides, carbon dioxide gas and smoke and dust, which will seriously pollute the environment. Biomass (straw) is one of the earliest, most extensive, and most direct utilization of human energy in renewable energy. However, biomass is widely distributed, burning energy is low, collection and transportation costs are high, post-treatment costs are expensive, calorific value is low, moisture content is high, and other heat sources are needed for use. Co- pyrolysis of coal and biomass can solve the problem of low utilization efficiency of pyrolysis. The research of which was performed by scientists both at home and abroad [1-8]. There are different opinions on whether synergy exists in co-pyrolysis. Yan and collaborators[9], used the co-pyrolysis experiment of biomass mixture and bituminous coal to prove that biomass powder can promote and inhibit the pyrolysis of coal to a certain extent.,believe there is synergy. Li Wen and Li Shiguang[10], however, showed that there was no obvious synergy between them. The co-pyrolysis of rice straw and Beishu coal was studied in this paper, and the synergistic effect of co-pyrolysis reaction was discussed.

II. Experimental

A. Materials

Rice straw used in this study was collected from Xuzhou farmland, Jiangsu, China. It was washed with de-ionized water, and dried in an oven at 60 ^{o}C for 5 h, then which was ground to pass through 100 mesh sieve and stored in a desiccator at room temperature before using.

B. Experimental Method

Coal and straw are pyrolyzed，respectively, and then mixed with straw and Beisu coal with TA thermogravimetric analyzer under pure N2 atmosphere, the flow rate is 60L/min, heated from room temperature to 1000 oC. The heating rates were 10 oC. min-1 and 20oC. min-1, respectively.

III. Results and Discussion

Figure 1 and Figure 2 showed TG and DTG of pyrolysis of BeiSu coal and rice straw. The volatiles of rice stalks begin to precipitate at about 200 ^{o}C, showing a rapid weight loss processat about 200 ~450 ^{o}C. The maximum weight loss rate is 302 ^{o}C. and then presents a slow process of thermal weight loss. When the temperature reaches 1000 ^{o}C, the pyrolysis weight loss is about 96%, and the pyrolysis of straw is almost complete. The weight loss rate of Beishu coal is slower than that of straw in the heating process. The volatile matter of Beishu coal precipitates mainly in the temperature range of 360 ~650 ^{o}C. The maximum thermal weight loss peak in DTG image corresponds to the weight loss temperature of 429 ^{o}C, and the total thermal weight loss in the pyrolysis process is about 50%.

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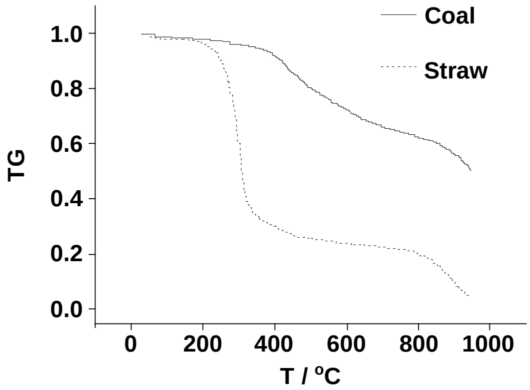

Figure 1. TG and DTG of pyrolysis of BS coal and rice straw

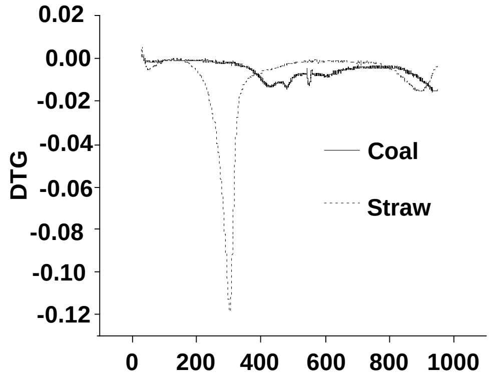

Figure 2. DTG of pyrolysis of BS coal and rice straw

TG and DTG of co-pyrolysis between coal and straw are showed in Figure 3 and Figure 4. As the proportion of Beisu coal in the mixture decreases, the weight loss of the mixture of straw and Beishu coal increases gradually during pyrolysis. In the pyrolysis process of straw and Beisu coal, two obvious pyrolysis peaks can be seen, which are mainly straw pyrolysis at low temperature (below 200 ~400 oC) and Beisu coal pyrolysis at high temperature (400 ~650 oC). The peak pyrolysis temperature of Beisu coal moves to the low temperature zone, while the maximum pyrolysis temperature of straw moves to the high temperature zone, indicating that during pyrolysis, straw and BeiSu coal have certain synergistic effect.

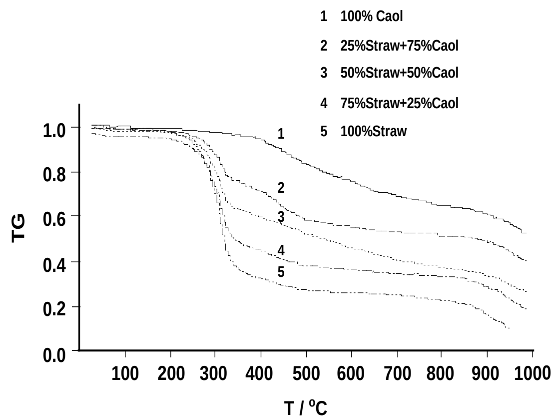

Figure 3. TG of co-pyrolysis between coal and straw

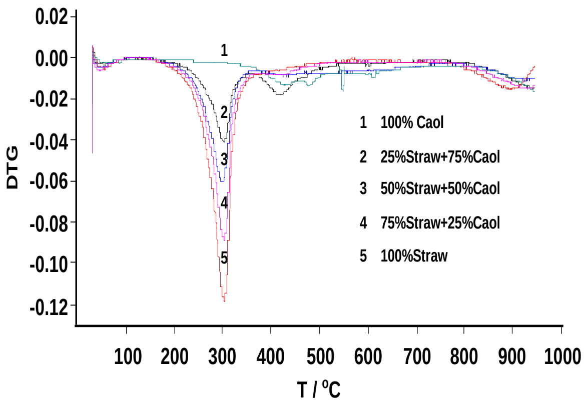

Figure 4. DTG of co-pyrolysis between coal and straw

The co-pyrolysis of Beishu coal and rice straw at a mass ratio of 3:1 at a heating rate of 10 oC.min-1 and 20 oC.min-1, respectively, was compared (Figure 5 and Figure 6). The higher the heating rate, the higher the temperature needed for the co-pyrolysis reaction of the mixture and the higher the residual of the co-pyrolysis products can be obtained. At the same temperature, the slower the heating rate is, the more fully the co-pyrolysis of the mixture is, and the less residual is. When the temperature reaches 900 oC, at 10 oC.min-1, the product residue is 40%, while at 20 oC.min-1, the product residue is 48%. That is, the increase of heating rate is beneficial to pyrolysis. With the increase of heating rate, the temperature difference inside and outside the blend particles is different, so that the pyrolysis atmosphere outside the mixture particles can not escape in time, further affecting the pyrolysis process inside the mixture.

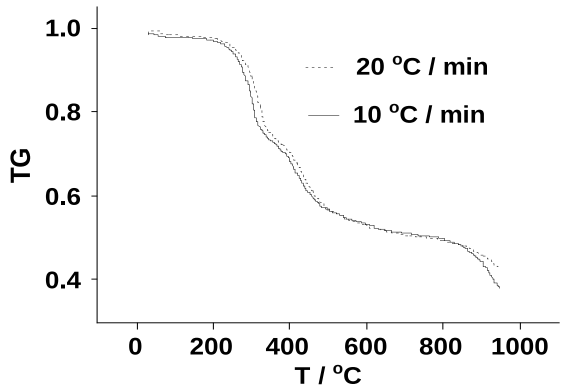

Figure 5. TG of effect of heating rate on co-pyrolysis of coal and rice straw

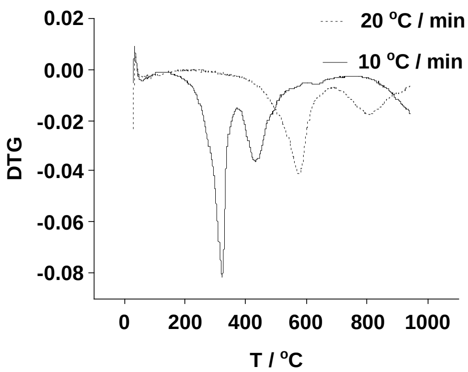

Figure 6. DTG of effect of heating rate on co-pyrolysis of coal and rice straw

IV. SUMMARY

In this study, pyrolysis of mixture of BeiSu coal and rice straw was investigated. With the proportion of Beishu coal in the mixture decreases, the weight loss of the mixture of straw and Beishu coal increases gradually during pyrolysis. Two obvious pyrolysis peaks can be seen, which are mainly straw pyrolysis at low temperature (below 200 ~400 oC) and Beisu coal pyrolysis at high temperature (400 ~650 oC). The increase of heating rate will result in the increase of temperature required for pyrolysis reaction of mixture and the increase of residual pyrolysis products. The synergistic effect existed in the pyrolysis process of coal and straw.

ACKNOWLEDGMENT

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