学 位 論 文 内 容 の 要 旨

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学 位 論 文 題 名

Study on End Face Combustion Behavior of Highly Densified Biomass Briquette
(高密度バイオマスブリケットの端面燃焼に関する研究)

End-face combustion experiments and one-dimensional calculations were conducted on cylindrical bio-coke (BIC), i.e., a highly densified biomass briquette, to investigate whether quasi-one-dimensional steady combustion can be attained in forced air flow with different air temperature and air flow rate, as measured by a steady regression rate.

In the experiments with 300K air flow, the air flow rate was the main test and the results showed that steady combustion of the BIC sample could be attained in 9.167NL/s or larger and, in contrast, extinction was observed in 7.50 NL/s or lower. In the calculation with 300K air flow condition, we obtained the mechanism that results in steady combustion and predicted the effect of BIC density and blowing on the extinction limit.

However, in the experiments with 400K air flow condition, it was found that the average regression rate in the first 0.01m of BIC was relatively small after ignition, whereas after the first 0.01m, the average regression rate became almost steady and much larger than that in the first 0.01m. This suggests that before the steady regression period is reached, a non-negligible unstable regression rate phase exists. We investigated this transient combustion phase by means of one-dimensional numerical calculations and the time-dependent regression rate and temperature distributions were computed. The mechanisms controlling transient combustion and the effects of volatile and moisture contents on transient combustion behavior were examined. The results show that a transient combustion period exists before steady combustion is achieved. This transient combustion period decreases as volatile content increases, and moisture content has a similar effect on transient combustion as volatile content. A rising tendency of transient combustion period is observed with the increase Bio-coke density. Lower air flow rate obtains longer transient combustion period. Such phenomenon can be explained by the different final steady temperature distribution and evolution rate from the initial temperature distribution to the final steady temperature distribution.

Finally, we investigated the effect air temperature on the transient combustion, results show the transient region becomes shorter but more evident as air temperature increases, which is due to remarkable increase of regression rate during the short transient period. That explains why we observe quasi steady combustion with 300K air flow.

In Chapter 1, we show the definition of biomass fuel and summarize the studies of pyrolysis and combustion behaviors of solid biomass fuel. Then we introduce our newly developed biomass fuel, Bio-coke (BIC), and elucidate our previous researches about BIC. Finally, objective and scope of this study are presented.

In chapter 2, we introduce the basic information of Bio-coke in detail, including the feedstock of

BIC, manufacture process of BIC, density, elemental analysis and proximate analysis of BIC. Finally, based on the thermogravimetric analyses, the kinetic parameters of drying and pyrolysis reaction of Bio-coke are obtained by means of multi-component devolatilization mechanisms and one-component mechanisms of primary pyrolysis, respectively.

In Chapter 3, the experimental setup (end-face combustion experimental setup) and procedure are described, as well as the one-dimensional numerical model.

In Chapter 4, steady combustion of Bio-coke is discussed both in calculation and experiment. The combustion reaches a steady state in high air flow rate (9.167NL/s or larger), but extinction is observed in low air flow velocity (7.50 NL/s or lower), and effects of Bio-coke density and blowing on extinction limit are investigated.

In chapter 5, end face combustion in the transient period between ignition and steady combustion has been investigated. A one-dimensional numerical model was established to study the change of regression rate and temperature distribution in BIC samples placed in opposed convective air flow and compared with experimental findings. Moreover, mechanism for controlling the transient characteristics of BIC end face combustion and role of the various parameters in the transient combustion stage is investigated.

In Chapter 6, conclusions are briefly summarized.