別紙４－１（課程博士（英文））

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Abstract (Doctor)

Title of Thesis	Study on Limiting Behavior of Smoldering Using Low Pressure

Approx. 800 words

Experimental study on limiting behavior of smoldering combustion, the transition to extinction or flaming from smoldering, was conducted with high reproducibility to clarify their precise mechanisms systematically. The considered ambient conditions in this study were 1.0 – 100 kPa in absolute pressure varying oxygen concentrations within 0.20 – 1.0 in mass fraction of oxygen. A 2-mm-rod-shaped biomass stick (incense stick) was considered as the test specimen as representative general charring fuels having bulk density and porosity similar to general wooden materials.

The smoldering behavior of the thin-rod biomass stick at low pressures and various oxygen concentrations was experimentally investigated for the vertically- and horizontally-oriented cases, aiming to examine the influence of a low-pressure environment on smoldering behaviors. In a low-pressure environment, the smoldering rates, the peak temperatures, and the thermal structures inside the biomass sticks were found to be nearly identical for both vertical and horizontal cases. This fact implies that role of the natural convection on combustion process was effectively suppressed using low pressure, suggesting that the effect of buoyancy-induced flow on the smoldering region becomes sufficiently small. In this way, the low-pressure method for examination for both extinction limit and transition to flaming from smoldering was verified.

The smoldering behavior near the extinction limit was then studied using the low-pressure method with the thin-rod biomass stick. It was found that the extinction limits were clearly affected by the imposed oxygen concentration. Having lower oxygen concentration below 0.4, the limit was achieved at certain smoldering rate. This limit was expected to be well-controlled by the transport (so-called transport-controlled regime) since oxygen transport to the smoldering region by natural convection was adequate for smoldering combustion, while the heat losses are more effective to lead to extinction. Having higher oxygen concentration above 0.4, on the other hand, the limit appeared at sufficiently low pressure where the transport process is severely suppressed. This limiting behavior is equivalent to one observed in the oxygen-limited regime, indicating that the oxygen-deficient condition limited the oxidation reaction. The extinction limit in the oxygen-limited regime showed a strong dependency on the imposed pressure, which is first ever observed/confirmed by this work.

The transition from downwardly (reverse) smoldering to flaming in a low-pressure environment was investigated to determine the dominant factor in

the critical condition of the transition. The reverse smoldering progressed steadily, although the lengths of the luminous region slowly increased with time under the conditions in which the partial pressure of oxygen is above 30 kPa. Introducing an image processing method, it was revealed that the luminous length at the point of transition showed strong dependency with the imposed partial pressure of oxygen. To examine their relationship, a simple ignition model referred by Semenov's theory was developed. It was confirmed that the predicted critical lengths when transition to flaming occurs were in good agreement with the experimental data, implying that the occurrence of the transition is mainly controlled by the heat balance between the heat release rate by oxidation reaction of the pyrolysis gases and the heat loss from the hot pyrolysis gases to the surrounding area when the concentrations of pyrolysis gases are enough to ignite.