Granular Bed Filtration of Nanoparticles Emitted from Biomass Burning

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Extended Abstract

Biomass fuel combustion can be a simplest solution for the increasing demands for renewable energy because of so-called “carbon neutral” and easy availability. However, the biomass combustion emits a large amount of air pollutants other than CO₂, or, ultra to fine particles, black carbon and hazardous organics such as PAHs and POPs, which cause various environmental problems and health risks. A large portion, around 50 wt% in some case (Hata et al., 2013), of smoke particles from wood combustion is categorized as PM₀.₁₅, or, “nanoparticles”, which can penetrate deeply inside respiratory system leading to large health risks. Many of these pollutants are emitted both from open burning and a numerous number of small scale biomass ovens or stoves just releasing smoke to the ambient environment without any facilities for the pollution control. The reason why the smoke from a small scale oven is directly released is mainly from cost problems for the installation and operation of pollution control devises.

In this study, a granular bed filter, which is a very much conventional filtration technique used, e.g., at elevated temperature conditions such that in hot gas cleaning systems (Furuuchi et al., 2004), was discussed on its abilities as a simple and low cost tool for the removal of nanoparticles from biomass burning. Filtration performance and pressure drop of granular bed filter were experimentally tested for various conditions of bed particle size, filtration velocity and filter thickness using a model bed filter of glass beads and compared with a semi-empirical prediction by Otani et al. (1989). An influence of morphology of bed particles on the separation performance and pressure drop was also investigated. The velocity of gas flow caused by so-called the “funnel effect” though a stuck of a commercial pellet stove was measured in relation to the temperature difference between the inlet and outlet of the stuck. The design and operating condition of a granular bed filter, which can be applicable to a commercial pellet stove, were also discussed.

The separation performance was well described by a prediction by Otani et al. (1989). The collection efficiency is more than 40% for PM₀.₁₅ at a small pressure drop of 80 Pa. Cup shape stainless steel grains provided a less pressure drop than spherical glass beads for the same separation efficiency. Based on the measured funnel flow velocity in relation to gas temperature difference through a stuck, filtration performance of the granular bed filter, the filter geometry and operating condition were successfully determined for a practical application to a commercial pellet stove.

References

