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Granular Bed Filtration of Nanoparticles Emitted from Biomass Burning

Masami Furuuchi, Mitsuhiko Hata
Kanazawa University, College of Science and Engineering, School of Environmental Design
Kakuma-machi, Kanazawa 9201192, Japan
mfuruch@staff.kanazawa-u.ac.jp; hata@se.kanazawa-u.ac.jp

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 CO_2, 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 $PM_{0.1}$, 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 $PM_{0.1}$ 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

Furuuchi, M., Hata, M., Kanaoka, C., Takahashi, R., Yagi, J., Takehama, R., Kawaminami, Y. (2004). Characterization and modeling filtration in a granular coke bed. Ceramic Transactions “Characterization & Control of Interfaces for High Quality Advanced Materials” by the American Ceramic Society, Vol.146, pp.365-373, ISBN: 1-57498-170-6

Hata, M. , Jumpa, W., J. Chomanee, S. Tekasakul, M. Furuuchi, Tekasakul, P. (2013). Measurement of Nano-particle Size Distribution Generated from Wood Biomass Combustion. Proc. 6th Int. Conf. Plasma Nanotech.& Sci. (IC-PLANTS 2013), Gero, Japan

Otani Y. et al. (1989).Experimental Study of Aerosol Filtration by the Granular Bed Over a Wide Range of Reynolds Numbers. Aerosol Science and Technology, 10(3), pp.463-474