空氣品質

街塵微粒的特性及利用複合過濾技術有效控制掃街車出風口微粒
Street dust particle properties and effective control of street sweeper exhaust using composite filters

Thi-Cuc Le, Thi-Thuy-Nghiem Nguyen, Zheng-Yu Peng, Tang-Yu Kuo, Chuen-Jinn Tsai*

[1]Institute of Environmental Engineering, National Yang Ming Chiao Tung University, Hsinchu 300093, Taiwan, *cjtsai@mail.nytu.edu.tw

Abstract

Street dust is a significant contributor to air pollution as it can be dispersed by wind erosion or vehicle driving activities, leading to the release of particulate matter such as total suspended particles (TSP), $PM_{10,}$ and $PM_{2.5}$ into the atmosphere. In Taiwan, street sweepers are commonly used to collect street dust and silt through sweeping and washing processes. However, these sweepers contribute to secondary particles emissions due to lack of effective particle control mechanisms after collection. This study aims to investigate the size fraction properties of street dust particles and develop an effective filtration system to capture emitted TSP, PM_{10}, and $PM_{2.5}$ particles. The proposed filtration system comprises 8-layer composite filters which is a combination of fibrous type demister filters. These filters are designed with four inner layers having the highest packing density (α: 0.11) and smallest fiber diameter (d_f: 0.2 mm), sandwiched between two middle medium coarse filter layers (α: 0.08; d_f: 0.4 mm) and two outermost mesh filters (α: 0.3; d_f: 0.77 mm). The fibrous demister filters are chosen for their long-term operation capability and ease of cleaning using water jets for reuse, especially effective when 65% of street dust particles have a large volume diameter of >297 μm. Three sets of the composite filters (51 x 61 x 2 cm) were installed at the street sweeper outlet operating at a low rate of 86 CMM (air velocity, U = 1.48 m/s) with an initial pressure drop (ΔP_0) of 43 Pa. The initial removal efficiencies for TSP, PM_{10}, and $PM_{2.5}$ were measured at 89.0 ± 2.76%, 79.58 ± 0.42%, and 46.03 ± 13.63%, respectively. Although the removal efficiency for $PM_{2.5}$ is moderate, it is still acceptable since $PM_{2.5}$ just accounted for 0.17% of street dust particles. Over time, the removal efficiency improved due to the accumulation of street dust particles on the filter surface, reaching 98.06 ± 1.70%, 97.29 ± 2.20%, and 96.68 ± 1.47% for TSP, PM_{10}, and $PM_{2.5}$, respectively, after 61.9 hours of operation, with a corresponding pressure drop of 996 Pa. After cleaning and re-installing the filters for continuous sweeping, the system's initial pressure drop and collection efficiency were fully recovered, demonstrating the system’s sustainability and operational reliability. In summary, the developed composite filtration system effectively mitigates secondary dust emission from street sweepers, offering a favourable benefit-to-cost ratio of 3.98.

Keywords: street sweeper, TSP, PM_{10}, $PM_{2.5}$, street dust, filtration system, composite filter