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Alternative filtration for management of indoor air quality in Seoul metro-subway

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ABSTRACT

Subway stations of Seoul Metro have individual mechanical ventilation chambers for air control (MVAC) to tickets and platforms. Screen doors recently built would improve the air quality inside by preventing from inflowing fine dust generated in tunnels. It enhances the efficiency of MVAC particularly in PM10 and PM2.5. An automatically working thin electrically charged filter was inserted behind the primary pre-filter. The field experimental work showed that the new filtration system could improve the dust collection efficiency without the significant increase of the flow resistance.

1. INTRODUCTION

National government has emphasized the significance of IAQ of metro-subway. Indoor air quality of Seoul metro-subway is of interest in both users and public authorities. In particular, fine dust level in platforms has been strictly controlled in association with the stringent regulation. The guideline of PM10 level in metro-subway is $140\mu g/m^3$. Thus, the present work focuses on fine dust for platforms and ticket spaces by applying double layer filtration system. A pre-filter at the front side is being operated all the times, but a second filter layer could work depending automatically on the fine dust concentration inside.

2. EXPERIMENTALS

A schematic diagram of the mechanical ventilation chamber for air control (MVAC) in the test subway with air filters is shown in Fig.1. Two type's filters were installed in a test MVAC. Filtration efficiency was observed in field station. The effects of two filters were examined with real-time analysis of PM10 and PM2.5 at several points of the platform and waiting room. Dust collection efficiency was evaluated by measuring inlet and outlet concentrations across the filter media by an optical aerosol spectrometer (Model 1.109, Grimm Aerosol spectrometer). Filtration performance was

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based on the mass concentrations as eq (1).

$$\eta_{mass} = 1 - \frac{C_{out,mass}}{C_{in,mass}} \tag{1}$$

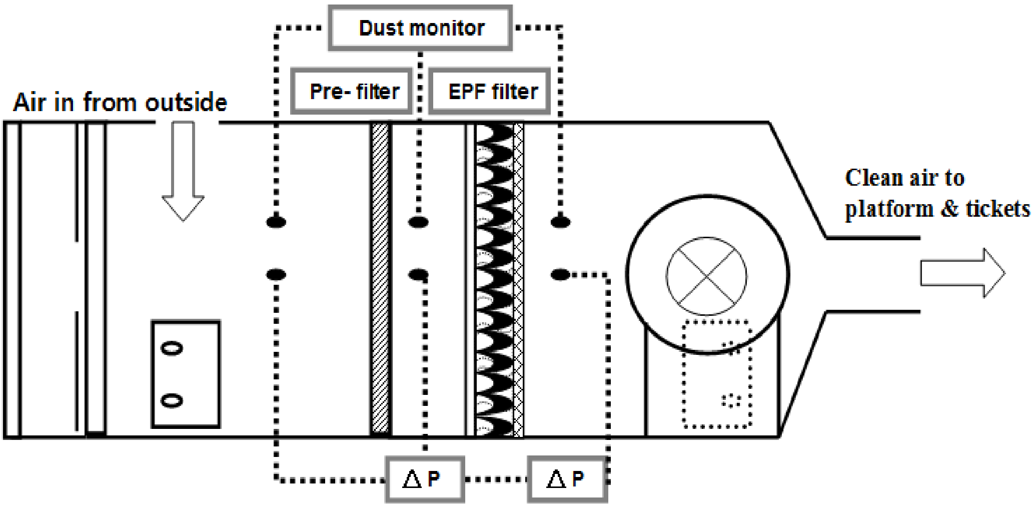

Fig.1 **Schematic diagram of MVAC in test bed station.**

3. RESULTS AND DISCUSSION

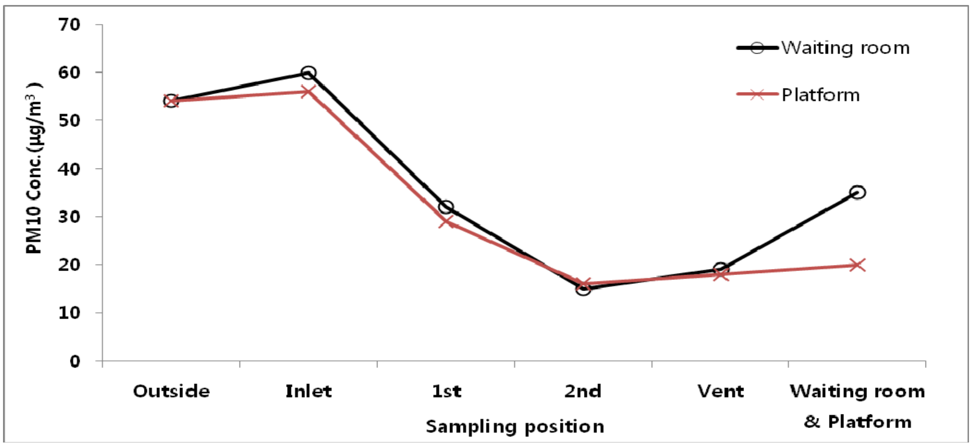

Fig.2 PM10 levels of each point in MVAC.

External air quality directly affects the inlet dust concentration for both PM10 and PM2.5 of the indoor. The inflow average concentration of PM10 during the test term was 40 $\mu g/m^3$ and 25 $\mu g/m^3$ for PM2.5. Fig.2 indicates dust concentration of inflow dust of each site. A large amount of fine dust could be collected by Pre-filter and newly added EPF. The dust concentration of inflowing at approximately 63 $\mu g/m^3$ dropped to 31 $\mu g/m^3$ as passing through a pre-filter. The additional electrostatic filter, EPF, could collect about 30% of the fed dust resulting in 15 $\mu g/m^3$. However, a slight increase of dust level was seen while flowing through the duct to the waiting room and platform. It may be due to residual dust inside the duct which would not be completely cleaned. Thus the periodical cleaning must be essential in order to supply the clean air. The dust concentrations found in the space of waiting room and platform were 35 $\mu g/m^3$ and 20 $\mu g/m^3$ respectively. Higher dust level in waiting room seems to be due to close effects by outside air quality. Frequent passes of people and passengers may bring the debris of street nearby and direct inflow of outside dust through the open gates.

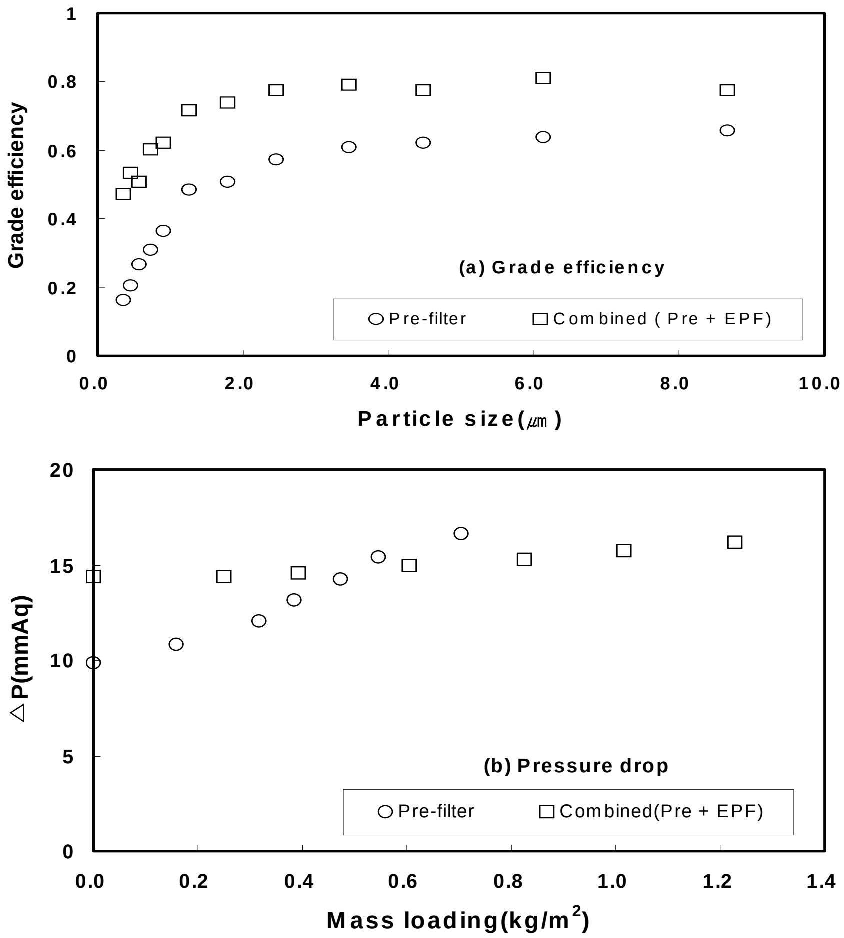

Fig. 3 Dust collection and pressure drop across the filtration unit.

Fig.3 is grade efficiencies of the existed pre-filter and a new layout of the filters. Both filters collect fine particles at moderate efficiency. The combined filters showed approximately 20% higher than a single pre-filter at throughout the particle size up to 10 μm. Pressure drop across the filter layers was seen quite interesting. As accumulating the dust, pressure drop has increased as usual, but the increasing rate was so high in pre-filter rather than combined filters. It implies that the new filter layers would collect the dust more effectively.

Fig.4 is a diagram of dust collection efficiency from the long term test in a field ventilation chamber. The collection efficiency of pre-filter reached at the maximum about 60% just before replacement usually in every two weeks. However, pressure resistance also rose as dust collection. Thus, it is a main purpose to install a low pressure resistance with high efficiency filter behind the conventional pre-filter. The pleated electret filter was chosen for the field test based on lab test. Double layer of two filters could provide more than 80% of dust collection, it has maintained for 84 days. Such two step filter layers assisted stable filtration performance 70 to 80% of TSP. Thus this new design may be able to control the indoor air quality better.

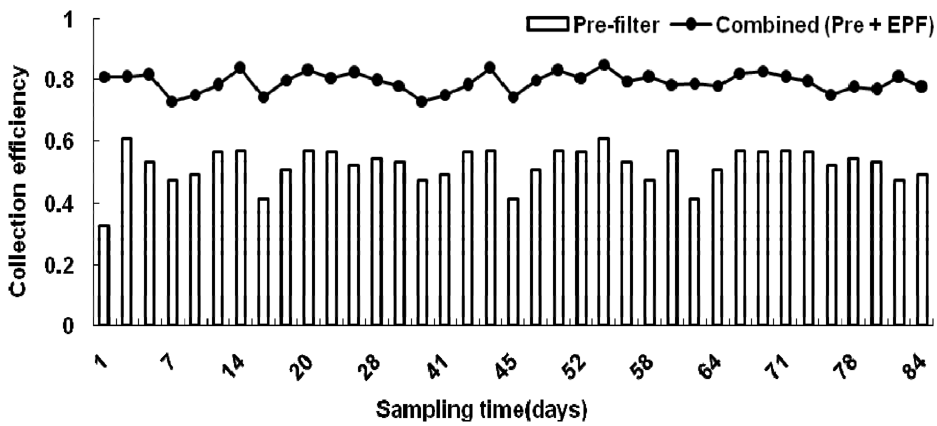

Fig.4 Dust collection efficiency in a field MVAC.

Fig.5 displays the field dust concentration for waiting room and platform. Pre-filter only was used in the first period, then the second EPF was inserted after the pre-filter and observed for more than two months. As predicted in a previous examination of the lab-test, two step filtration presented more consistent air quality for both waiting room and platform. The dust concentration of the waiting room however maintained a bit higher than platform because of more open spaces to the outside. The control air volume of MVAC must be well designed to overcome the effects by external air. Meanwhile since the platform is relatively isolated from outside and tunnel, clean air could maintain with the aid of sufficient supply of filtered air from MVAC.

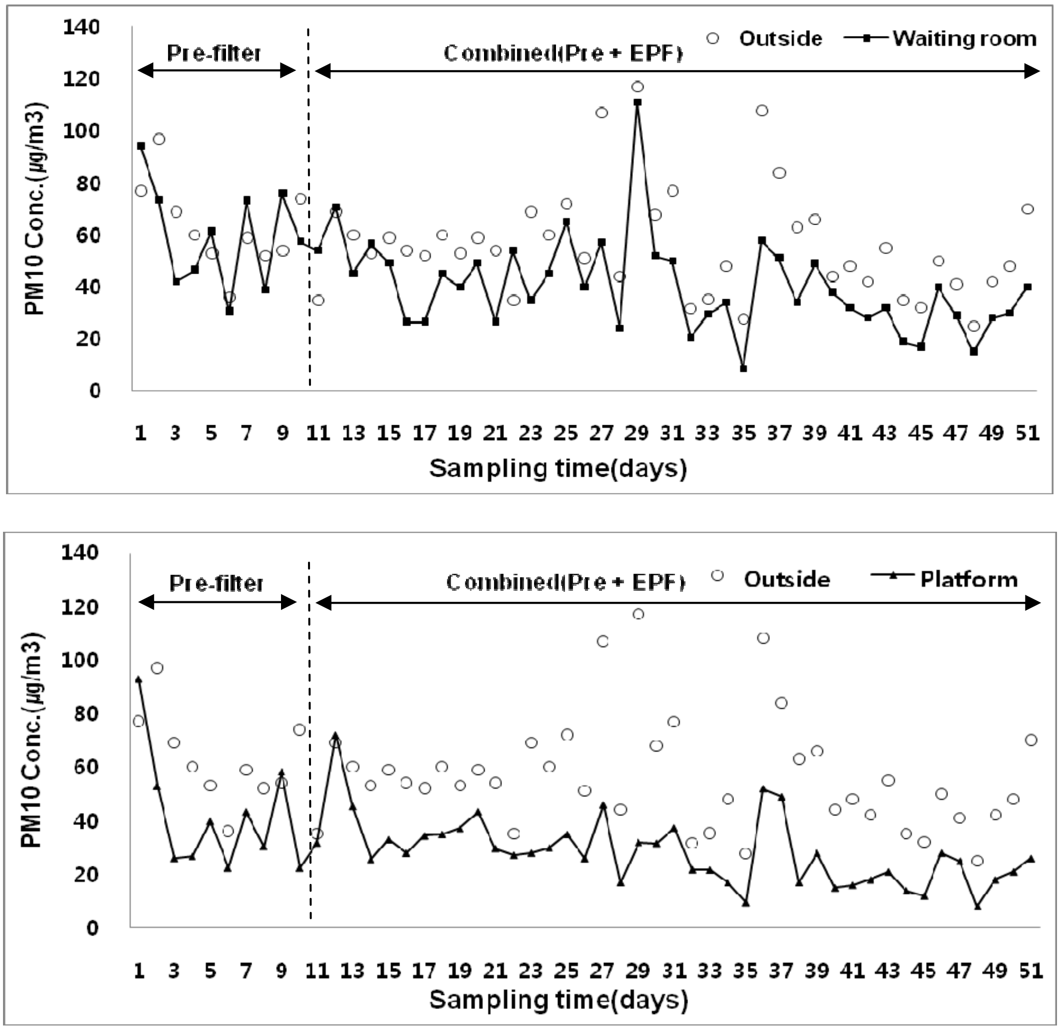

Fig. 5 Long-term examination of current filters.

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