The 2012 World Congress on
Advances in Civil, Environmental, and Materials Research (ACEM' 12)
Seoul, Korea, August 26-30, 2012

Development and Application of Filtering System for NO_2 removal in a Subway Station

Ho-Joon Choi[1)] and Jin-Ho Jeong[1)] and Youn-Suk Son[2)] and Jun-Seok Hong[1)] and *Jo-Chun Kim[1, 2)]

[1)] Department of Environmental Engineering, Konkuk University, Seoul 143-701, Korea
[2)] Department of advanced Technology Fusion, Konkuk University, Seoul 143-701, Korea
[1), 2)] jckim@konkuk.ac.kr

ABSTRACT

Subway air quality is known to have something to do with indoor and outdoor emission sources. In general, NO_2 caused by automobiles flows into the subway through ventilating openings and stairs, and has harmful effect on passengers. To solve this problem, in this study, the control work of NO_2 using mixed activated carbon filter has been carried out. Besides, control efficiency and energy consumption were evaluated by fan power and the angle of the filter panel in order to get economical control. Furthermore, NO_2 concentrations were measured before and after the filter system, and the control efficiency of NO_2 by changing inverter frequencies (20, 30, 40Hz) was obtained. In particular, when the angle of filter panel changed to 45˚ (position at low inlet concentration of NO_2), power consumption was saved by approximately 40%.

1. INTRODUCTION

Nowadays, citizen's residence time in indoor areas increases because of rapid development and urbanization. Therefore, the indoor air quality became very pivotal in aspect of health and quality of life (Cho et al., 2005). It is well known that air quality of the subway which has been used as citizen's commute means is affected by indoor and outdoor emission sources. NOx is a representative air pollutant. The chemical is emitted from automobiles and flows into the subway through ventilating openings and stairs, and causes harmful effect on passengers (Chan et al., 2003). Ventilating openings in subway systems have significant roles in filtering outdoor air and inducing filtered outdoor air into subway systems. However, currently most of these were worn out and could remove only big particulate matters (Johansson et al., 2003; Kim et al., 2007). To solve these problems, many control technologies have been used. However, they have technical limits in terms of installation and management cost, and the size of installation space. Especially, NO_2 control method using adsorption with mixed activated carbon has been recently introduced so as to overcome several problems (Son et al., 2011). In this study, a research to get optimum NO_2 control efficiency was carried out with respect to three operation factors, such as pressure drop, removal efficiency, and external void fraction of adsorbent. Also, on the basis of these results, control efficiencies by inverter frequencies (20, 30, 40Hz) and power consumption by the angle of panel were evaluated to achieve an economical output.

2. EXPRIMENTAL METHODS

2.1. Field Experiment

Mixed activated carbon filter made by the constructed activated carbon and the granular activated carbon in the proportion of 2:1 was installed in the HVAC system which induced the outdoor air into a subway station. NO_2 concentrations were measured before and after the filtering system, and the control efficiencies of NO_2 were obtained by changing inverter frequencies (20, 30, 40Hz). When the angle of filter panel was changed from 90˚ (vertical position) to 45˚ (position at low inlet concentration of NO_2), the actual operating values of inverter frequency and power consumption were measured at the status of the same linear velocity.

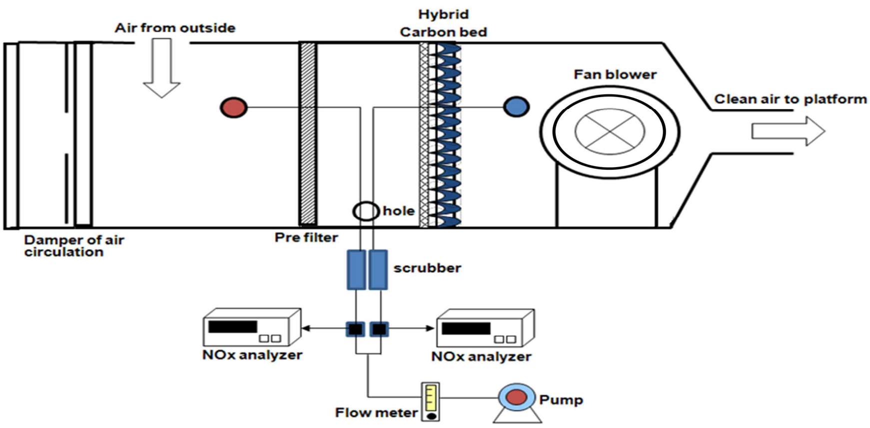

Fig. 1 Schematic of control system in a subway HVAC system

2.2. Analytical Method

NO_2 concentrations were measured using two NOx Analyzers (Model 32i, Thermo Scientific, USA) before and after a mixed activated carbon filter. NOx Analyzer was used at a flow rate of 0.7L/min. A membrane filter (0.45 ㎛ × 47 mm, Membrane filters cellulose nitrate, MFS®, USA) was used at the sample suction part of the NOx analyzer to minimize the interference of particulate matters.

RESULTS AND DISCUSSION

NO_2 control efficiency of mixed activated carbon filter and break-through time (i.e., control efficiency was less than 10%) was measured according to inverter frequencies (20, 30, 40Hz). The efficiency was initially about 75% and deceased as time went by. When inverter frequencies were 20, 30, 40Hz, break-through time was 384hr (16days), 336hr (14days) and 288hr (12days), respectively. It was confirmed that the inverter frequency gradually increased and break-through time was shorten. When the angle of filter panel as the operation factor of associated control system was changed from 90˚ to 45˚, inverter frequencies were decreased from 20, 30, and 40 to 12, 18, and 26 respectively. This indicated that power consumptions were saved by approximately 40%.

CONCLUSIONS

This study was carried out for NO_2 control in the subway station. Mixed activated carbon filter was installed in a HVAC system that brings outdoor air into a subway system. And, the decreasing rate of NO_2 concentration and the lifetime of filter were examined. After mixed activated carbon filter has been applied, the control efficiency of NO_2 in a HVAC system was initially 75%; however, the control efficiency of NO_2 in a platform was approximately 40%. It was revealed that outdoor air including dirty pollutants was flew into subway station by several routes, such as stairs, tunnel, trains, ventilating openings and HVAC system. Besides, when the inverter frequency gradually increased, lifespan of absorbent was shorten. It was found that the total volume of inflow air with pollutants were also increased since the inverter frequency was increased, As well, when the angle of a filter panel was changed from 90˚ to 45˚, the actual power consumption and inverter frequency were reduced, and the lifespan of absorbent was extended. On the basis of these results, when mixed activated carbon filter was applied to control systems associated with subway stations, it was concluded that NO_2 concentration could be maintained below the indoor air quality standard of KMOE and the power consumption would be saved.

ACKNOWLEDGEMENT

This project has been supported by Seoul R & BD Program (CS070160).

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