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Experimental research on impact of SCR to diesel buses' emission

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Abstract. The emission experiments of a traditional diesel bus and a SCR diesel bus on a selected expressway in Shenzhen city are carried out with a high-precision mobile emission tester. The experiment data are calculated and the buses' emission characteristics are analyzed. The study shows that the SCR bus NO_X emission is higher than the traditional diesel bus when the buses' velocity is slow and lower than the traditional one when the velocity is fast. The higher velocity on expressway can help SCR diesel buses increase NO_X transfer efficiency and reduce NO_X emission because that the tailpipe exhaust temperature is high when the diesel bus runs fast.

1 Introduction

The buses in Chinese cities are mostly diesel buses. The data from a famous bus company in Shenzhen city show that the diesel buses account for 83% of total 3908 buses in this company. The government data show that there are 11170 diesel buses, 580 LNG buses, 1279 pure electric buses and 1771 hybrid electric buses in Shenzhen city until the end of 2014. It means that the diesel buses account for 75% in this city.

The main harmful components in diesel bus tailpipe exhaust are NO_X and PM. NO_X is toxic and may cause photochemical smog which can lead to vision problem, headache, chest pain and even death. It is more and more urgent to reduce diesel bus NO_X emission to protect the natural environment and to meet the stricter and stricter emission regulations.

The SCR technology has been utilized for the diesel vehicles to meet stage 4 or 5 national emission standard, especially the heavy diesel buses and trucks. The SCR operational principle is to inject urea and water at a special ratio into diesel vehicle tailpipe exhaust and transfer NO_X in the tailpipe exhaust into NH_3 and water with the help of high exhaust temperature and some special catalysers [1][2][3][4].

2 Experiment design

The SEMTECH-DS portable emission analyser is used to measure the NO_X emission of a SCR diesel bus and a traditional diesel bus on a selected expressway in Shenzhen city. The experiment system is shown as figure 1. The exhaust flow meter (EFM) is used to measure the tailpipe exhaust flow rate and the tailpipe exhaust temperature. A sampling pipe in the EFM samples the tailpipe exhaust and delivers the sample gas to the portable emission analyser to calculate instantaneous CO, NO_X and HC emission rates. The portable emission analyser includes the Nondispersive Infrared Analyzer (NDIR) which measures CO and CO_2, the Non-Dispersive Ultra-Violet Analyzer (NDUV) which measures the NO_X and the Heated Flame Ionization Detector (HFID) which measures HC. The temperature hygrometer and the Global Positioning System (GPS) measure the environment temperature/humidity and the vehicle velocity. Then the experiment data are delivered to the portable emission analyser. The PC which connected with the portable emission analyser could zero, calibrate and supervise the experiment system and collect the experiment data.

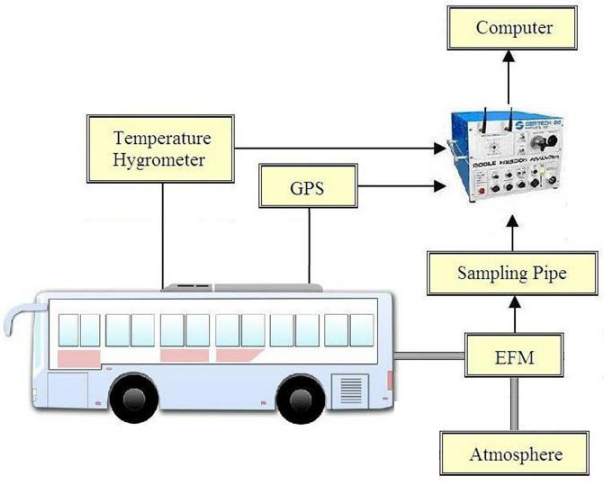

Figure 1. Experiment system sketch diagram.

The experiments are carried out on a typical expressway in Shenzhen city. The selected expressway is the famous beautiful Binhai Road which travels across Nanshan business district, Futian business district and Luohu business district in the south of Shenzhen city. The

Binhai Road is also near the coastal park and the bird reserve. There are lots of diesel buses run on the Binhai Road and the diesel bus NO_X emission can affect the health of millions of citizen in this city. The total diesel bus NO_X emission experimental mileage on the Binhai Road is about 15.5 km.

The selected diesel buses for NO_X emission experiments are two kinds of familiar diesel buses in Shenzhen city. The traditional diesel bus is manufactured by Yutong Bus Co., Ltd, the most famous bus company in China. The SCR diesel bus is a Higer diesel bus manufactured by Dragon joint Automobile Industry Co., Ltd, another famous bus company in China. The diesel buses' parameters are shown as table 1.

Table 1. The parameters of two diesel buses.

Type	Traditional Diesel Bus	SCR Diesel Bus
Brand	Yutong	Higer
Mileage(km)	168449	167549
Grass Mass(kg)	16500	17000
Length(m)	11	11
Engine Power(kW)	192	191

3 Experiment result

The experiments are carried out with an experiment system that is composed of a GPS, an exhaust flow meter and a mobile exhaust analyzer, etc. During the experiment, the traditional diesel bus and the SCR diesel bus are driven by the same driver. The experiment beginning time is also the same. So the interfere of human factor and traffic condition can be minimized as far as possible.

All bus velocity data and instantaneous NO_X emission rate data are collected by the SEMTECH-DS portable emission analyzer. The velocity data and the instantaneous NO_X emission rate data of the traditional diesel bus during the whole experiment period are shown in figure 2. The velocity data and the instantaneous NO_X emission rate data of the SCR diesel bus during the whole experiment period are shown in figure 3.

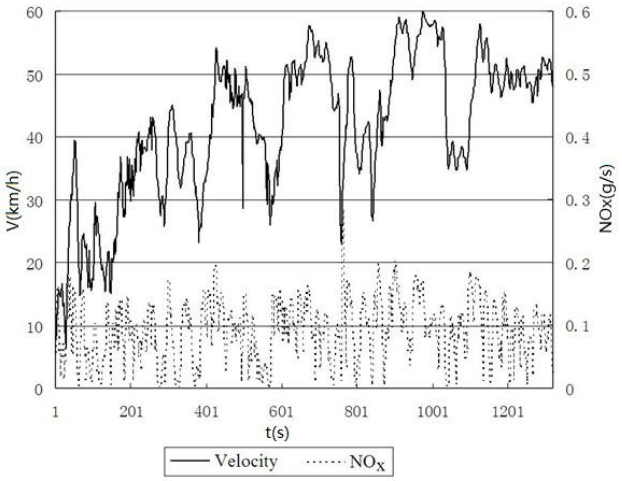

Figure 2. Instantaneous NO_X emission data of the traditional diesel bus.

The data shows that emission peaks appear mostly in rapid accelerating periods. Some Chinese scholars' research also shows the same rules [5][6][7]. NO accounts for 90% of NO_X in diesel engine tailpipe exhaust. The high diesel engine temperature will cause NO emission peaks [8]. High diesel bus velocity and rapid acceleration may lead to high diesel engine temperature.

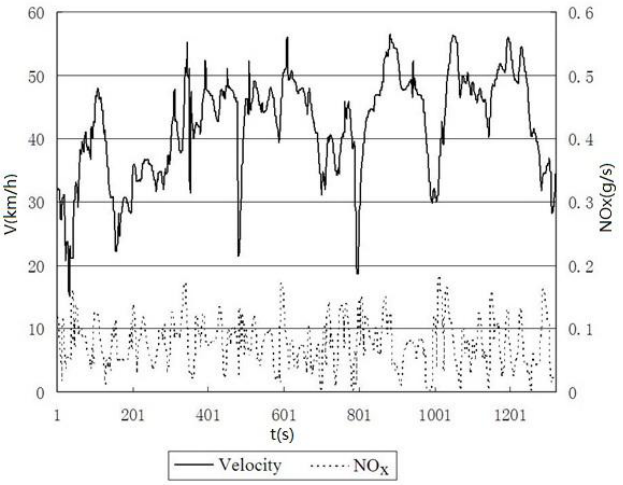

Figure 3. Instantaneous NO_X emission data of the SCR diesel bus.

4 Average emission rate characteristics

The experiment data are divided into 13 intervals for every 5 km/h from (0, 5], (5, 10] to (55, 60]. The intervals are named from Q0, Q1 to Q12. The average NO_X emission rates (g/s) of the traditional diesel bus and the SCR diesel bus are calculated in every interval. The values of two experiment buses are shown in figure 4.

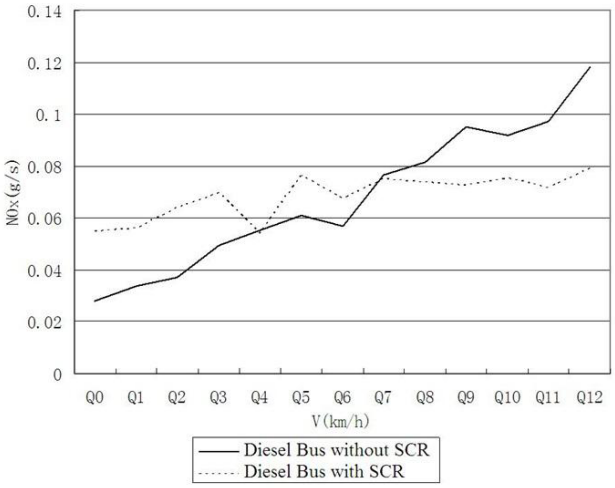

Figure 4. Average NO_X emission rates of two diesel buses.

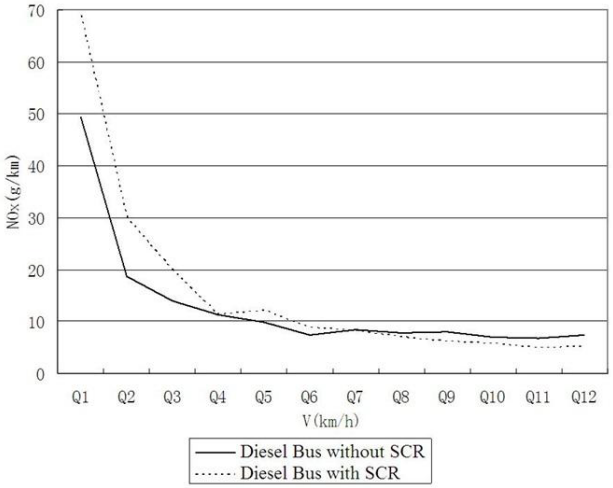

Figure 5. Average NO_X emission factors of two diesel buses.

Figure 4 shows that average NO_X emission rates of the traditional diesel bus rise up with the diesel bus velocity due to the rising engine temperature. Average NO_X emission rates of the SCR diesel bus are higher than the traditional diesel buses when the bus speed is slow and lower than the traditional one when the bus speed is fast. The SCR system efficiency depends on the tailpipe exhaust temperature. When the temperature is rising with the velocity, the catalyser efficiency will rise up and the NO_X transfer efficiency will be increased and the NO_X emission will be reduced. The research of a Chinese scholar shows that the NO_X transferring efficiency will rise up with the diesel bus exhaust temperature when the temperature is beneath 350ºC [5]. The experiment data show that the tailpipe exhaust temperature of two diesel buses is lower than 300 ºC during the whole experiment. So the SCR system efficiency rises up with the velocity during the experiment.

5 Average emission factor characteristics

The experiment data are divided into 13 intervals for every 5 km/h from (0, 5], (5, 10] to (55, 60]. The intervals are named from Q0, Q1 to Q12. The average NO_X emission factors (g/km) of the traditional diesel bus and the SCR diesel bus are calculated in every interval. The values of two experiment diesel buses are shown in figure 5.

The figure shows the NO_X emission factors of two diesel buses fall when the speed rises. When the diesel bus velocity is slow, the NO_X emission factor falls rapid with the velocity. It means that the air quality will be improved when the diesel bus velocity in urban area is high. When the diesel bus velocity is beneath 30km/h, average NO_X emission factors of SCR diesel bus are higher than traditional diesel bus. When the diesel bus velocity is above 35km/h, average NO_X emission factors of SCR diesel bus are lower than traditional diesel bus.

6 Net emission mass

The net NO_X emission mass of the traditional diesel bus and the SCR diesel bus are calculated. The net NO_X emission mass of SCR diesel bus is 94.57g and the value of traditional diesel bus is 110.95g which is 17.3% higher than SCR diesel bus. It shows as Figure 6. It means that the SCR system can help reduce NO_X emission on city expressway.

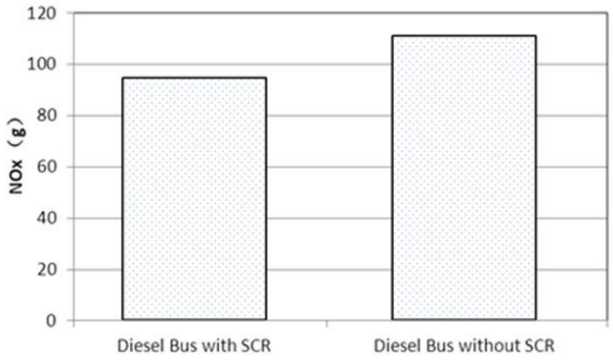

Figure 6. Net NO_X emission mass of two diesel buses.

7 Summary

The NO_X emission experiment between a traditional diesel bus and a SCR diesel bus are carried out on city expressway with SEMTECH-DS portable emission analyzer. The experiment system can collect the velocity data, the instantaneous NO_X emission rate data, the temperature data and the humidity data, etc.

The instantaneous NO_X emission rate peaks of two diesel buses appear when the diesel bus runs fast or accelerates rapid. The high diesel speed and the rapid acceleration can cause the high diesel engine temperature. The NO_X emission will increase obvious because of high temperature.

The average NO_X emission rates of two diesel buses rise with the bus velocity. The average NO_X emission

rate of SCR diesel bus is higher than the value of traditional diesel bus when the diesel buses run slow. The average NO_X emission rate of SCR diesel bus is lower than the value of traditional diesel bus when the diesel buses run fast.

The average NO_X emission factors of two diesel buses decrease with the bus velocity. The value decreases rapid with the bus velocity when the diesel buses run slow and decreases slow when the buses run fast. It means the high diesel bus velocity can reduce NO_X emission effectively.

The net NO_X emission mass of traditional diesel bus is 17.3% higher than the value of the SCR diesel bus in the whole experiment mileage. The SCR technology can help reduce NO_X emission on city expressway.

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