Research on the Status Quo of In-use vehicle Environmental Protection Regular Inspection in Tangshan

Xiaowen Zhang¹, Jiguang Wang¹,², Zhenyu Bai³

¹China Automotive Technology and Research Center Co., Ltd., Tianjin 300300, China
²University of Science and Technology of China, Hefei 230026, China
³Tangshan Environmental Monitoring Center, Tangshan 063099, China

Abstract. The project team collected more than 1 million in-use vehicles environmental protection regular inspection data for analysis, the data of annual inspection in Tangshan area are sorted out and analyzed, the conclusion is as follows: 1. The weighted average qualification rate of each inspection method for in-use vehicles in Tangshan was 87.9%. 2. The weighted average qualification rate of different emission stages of VMAS is 88.7%, the weighted average qualification rate of different emission stages of TSIC is 93.9%, the weighted average qualification rate of Frac in different emission stages is 98.3%, and the weighted average qualification rate of LUGDOWN in different emission stages is 77.8%. 3. After the implementation of the new standard, the qualified rate of TSIC and LUGDOWN in Tangshan will be greatly reduced, but it has little influence on the qualified rate of VMAS and FA.

1 INTRODUCTION

China has become the world's largest country in the production and sale of motor vehicles for nine consecutive years. Motor vehicle pollution has become an important source of air pollution in China and an important cause of ambient air pollution. The urgency of motor vehicle pollution prevention is increasingly prominent. At present, 31 provinces across the country have carried out regular emissions inspections of motor vehicles. As of the end of 2018, a total of 175.841 million vehicles have participated in regular environmental inspections across the country, accounting for 76.0% of the country's car ownership. Shanghai, Chongqing, Anhui and other three provinces and cities have regular environmental protection emission inspection rates of 90.0%[1]. According to regulations, all test data must be uploaded to the motor vehicle emissions supervision department. Tangshan is an important core city in the Beijing-Tianjin-Hebei region and an important part of the “2 + 26” air pollution transmission channel[2]. How to effectively use these detection data for big data analysis based on regular environmental protection emissions, including data acquisition, storage, management, analysis and mining, visualization and other technologies and their integration [3-4]. Through the application of big data analysis, it can not only bring huge economic benefits, but also effectively improve the level of social management, and has important social and economic values [5-6], in order to better serve motor vehicle emissions supervision, it has become an important issue for environmental regulatory authorities [7].

2 DATA SOURCE

The project team has, from Tangshan Environmental Monitoring Center, collected a total of over one million pieces of data of regular inspection for environmental protection of in-use vehicles in the whole city of Tangshan from April 2018 to April 2019. Tangshan city adopts Two-speed Idle Conditions (TSIC), Vehicle Mass Analysis System (VMAS), Free Acceleration (FA) and Lugdown Cycle (LUGDOWN), among which TSIC and VMAS are used to test gaseous pollutants of gasoline vehicles, FA and LUGDOWN are used to test smoke of diesel vehicles, and the data sample distribution of different testing methods is shown in Fig. 1.

![Fig.1 The data sample distribution of different test methods](image-url)
As the current vehicle emission standard has not clearly stipulated the items to be recorded and the method of recording, the lack of standardized management of test results has led to the failure of conducting effective statistical analysis on nearly 0.12% of the total data samples. Therefore, unified standards should be proposed in the future for vehicle inspection equipment, control software and data information to improve the accuracy and effectiveness of data inspection.

3 REGULAR ANALYSIS ON DATA OF ENVIRONMENTAL PROTECTION TESTS

This study analyzes the qualification rate of different testing methods. The weighted average qualification rate is used to comprehensively evaluate the emission qualification of each detection method, and its calculation formula is as follows:

$$\bar{x} = \frac{\sum_{i=0}^{n} (y_i f_i)}{\sum_{i=0}^{n} f_i}$$ (1)

Where $y$ is the qualification rate and $f$ is the qualified weight.

The total weighted average qualification rate of each method is 86.9%. As the different detection methods and emission limits are different, the qualification rates vary correspondingly. The qualification rates of non driving condition methods, such as FA and TSIC, are relatively high, both of which are higher than 90%; while the qualification rates of driving condition methods, such as VMAS and LUGDOWN, are relatively low, of which the qualification rate of LUGDOWN is 77.1%.

According to the environmental protection industry standard "the principle and method of confirm limits for exhaust pollutants from in-use vehicle equipped ignition engine under simple driving mode conditions" (HJ/T240-2005) and "the principle and method of confirm limits for exhaust smoke from lug-down mode for in-use motor vehicles with C.I.E." (HJ/T241-2005), the determined emission limits shall be able to effectively detect high emission vehicles, and it is recommended to confine the urban control rate of high emission vehicles at 10% - 20%. In the light of this principle, this research uses the corresponding emission interval when the cumulative distribution ratio is 75% to 90% as the performance interval of our city's emissions[8-9].

3.1 VMAS

The weighted average qualification rate of different emission stages of VMAS is 88.7%. From the perspective of emission stage, the emission requirements of pre National I, National III and National IV emission standards are relatively low, and the qualification rates are high; except for pre National I emission stage, the qualification rates of other emission stages are gradually increasing (Shown in Fig. 2).

Fig.2 The qualified rate of VAMS in different emission standards

It can be concluded after analysis of actual emission data that the over standard emission of vehicle pollutants accounts for 50.39% of the total vehicle emissions. Fig. 3 shows the distribution of unqualified vehicles and the total proportion of unqualified items. As can be seen from Fig. 3, high CO emission is one of the important reasons for failing annual inspection.

Fig.3 Each stage of emission distribution of non-conformity and the total proportion of unqualified items

Through the emission values actually detected by the cumulative distribution, the emission values corresponding to different cumulative distribution proportion of each pollutant under VMAS can be obtained, as shown in Figure 4. The emission performance intervals of CO and HC+NOx are respectively 3.85-7.84 g/km and 0.69-1.94 g/km (the gray area in Figure 3), and the black dotted line in Figure 4 is HJ/T240-2005 the reference minimum emission limit value of VMAS, and the red
dotted line represents the reference minimum emission limit value of VMAS in GB18285-2018. In the new standard GB18285-2018, both HC and NOx have limited values. We add them and mark them in Fig. 4 (b) for reference. It can be seen that, after the new standard is implemented, the qualification rate under VMAS in our city will decline to some extent, but the overall decline is not significant.

Through the emission values actually detected by the cumulative distribution, the emission values corresponding to different cumulative distribution proportion of each pollutant under TSIC can be obtained, as shown in Fig. 6 and Fig. 7. The emission performance interval (volume fraction) of CO at low and high idle is respectively 0.06%~0.16%, 0.05%~0.16%, the emission performance interval (volume fraction) of HC at low and high idle is respectively 43.68*10^{-6}~88.82*10^{-6}, 42.84*10^{-6}~82.86*10^{-6} (the gray area in Figure 6 and Figure 7), while the black dotted lines in Figure 6 and Figure 7 are the minimum emission limit of high and low idle of GB18285-2005, and the red dotted lines are the minimum emission limit of high and low idle of GB18285-2018. It can be seen that after the new standard is implemented, the CO emission can still be further lowered before reaching the minimum emission limit, and the HC minimum emission limit is relatively low. Generally speaking, after the implementation of the new standard, the qualification rate of TSIC will be greatly reduced.

The weighted average qualification rate of different emission stages of TSIC is 93.9%. From the perspective of emission stage, the emission requirements of National IV and National V emission standards are relatively low, and the qualification rates are high, both around 95%, and the qualification rate of each emission stage is gradually increasing (Shown in Fig. 5).
3.3 FA

The weighted average qualification rate of FRAC in different emission stages is 98.3%. From the perspective of emission stage, due to the low emission requirements in the pre National I emission standard, the qualification rate is higher, while the number of vehicles in the pre National I emission stage is relatively small, accounting for only 0.22% of the data, and the qualification rates in other emission stages are gradually increasing (Shown in Fig. 8).

Through the emission values actually detected by the cumulative distribution, the emission values corresponding to different cumulative distribution proportion of free accelerating smoke can be obtained, as shown in Figure 9. The recommended emission limit of free acceleration smoke is light absorption coefficient 0.25 m⁻¹~0.63 m⁻¹ (gray area in Figure 9), while the black dotted line in Figure 9 is the minimum emission limit of free acceleration smoke in GB3847-2005, and the red dotted line is the minimum emission limit of free acceleration smoke in GB3847-2018. It can be seen that the implementation of the new standard will not cause a significant impact on the qualification rate of FA.

3.4 LUGDOWN

The weighted average qualification rate of LUGDOWN in different emission stages is 77.8%, which is generally lower than other detection methods. As the number of vehicles before National I emission standard was very small, only accounting for 0.02% of the data, it is no longer taken into the qualification rate comparison. From the perspective of emission stage, the qualification rate gradually increases with different emission stages (as shown in Figure 10).
Fig.10 The qualified rate of LUGDOWN in different emission standards

Through the emission values actually detected by the cumulative distribution, the emission values corresponding to the different cumulative distribution proportion of lug-down smoke can be obtained, as shown in Figure 11. In LUGDOWN, the smoke coincidence is higher under the three wheel power \((80\%, 90\%, 100\%)\), and the project team selects 100% of the working points as the research data to simplify the calculation process. The light absorption coefficient emission performance range is 0.83-2.00m\(^{-1}\) (the gray area in Figure 11), while the black dotted line in Figure 11 is the minimum emission limit of the load deceleration method in HJ/T241-2005. As there is only one vehicle produced before July 2000 in the data, we choose the minimum emission limit implemented upon vehicles of which the first one was produced after July 1, 2000. The red dotted line in Figure 11 is the minimum emission limit of LUGDOWN in GB3847-2018. It can be seen that the minimum emission limit of lug-down smoke is relatively low. After the implementation of the new standard, the qualification rate of LUGDOWN will be greatly reduced.

Fig.11 The cumulative percentage of pollutant emission of LUGDOWN

4 CONCLUSIONS

The project team has collected more than one million pieces of data of environmental protection regular inspection on in-use vehicles for analysis. The weighted average qualification rate of each inspection method of in-use vehicles in Tangshan is 87.9%. Due to the problems of inspection methods and emission limits, the qualification rates of different inspection methods are quite different. FRAC and TSIC are non driving condition methods, and the qualification rates are relatively high, both of which are over 90%; VMAS and LUGDOWN are driving condition methods, and the qualification rates of LUGDOWN is relatively low, which is 73.5%. After the implementation of GB18285-2018 and GB3847-2018, it will have a certain impact on the qualification rate of in-use vehicles, especially for TSIC and LUGDOWN, as the qualification rates of the two methods will be greatly reduced.

References

1. Ministry of Ecology and Environment of the People’s Republic of China. China Mobile Source Environmental Management Annual Report (2019)[R]. Beijing: Ministry of Ecology and Environment, 2019.
2. Ministry of Ecology and Environment of the People’s Republic of China. Beijing-Tianjin-Hebei and surrounding areas air pollution prevention work plan in 2017[J]. China Environmental Management, 2017(9).5.
3. MANYIKA J, CHUI M, BROWN J, et al. Big data: the next frontier for innovation, competition, and productivity[R]. Washington, D.C.: McKinsey Global Institute, 2011.
4. MCAFEE A, BRYNJOLFSSON E. Big data: the management revolution[J]. Harvard Business Review, 2012, 90(10):3-9.
5. Mo Qifu. Social value and strategic choice of big data[J]. Motherland, 2018(6): 63-63.
6. Tao Xidong. The Path and Strategic Choice of Social Governance Innovation of China in the Era of Big Data [J]. Nanjing Journal of Social Sciences, 2016(6):85-90.
7. MA Dong, YIN Hang, DING Yan, et al. Research on the emission status of in-use vehicle in China based on big data analysis [J]. Environmental Pollution & Control, 2016 (7):42-48.
8. HJ/T240-2005, The principle and method of confirm limits for exhaust pollutants from in-use vehicle equipped ignition engine under simple driving mode conditions [S].
9. HJ/T241-2005. The Principle and method of confirm limits exhaust smoke from lug-down mode in-use motor vehicles with C.I.E.(Compression Ignition Engine) [S].