Academic Journal of Science and Technology
ISSN: 2771-3032 | Vol. 7, No. 1, 2023

Research on Feature Detection of Light Vehicle Emission Pollution Under the Control of Artificial Intelligence

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Abstract: Most modern cars use electronically controlled fuel injection engines. Because the fuel injection rate is strictly in accordance with the intake port, the combustion is more thorough and cleaner, so it usually has better emission performance. However, when there is a problem with it, it will have a great impact on its emission characteristics. By conducting exhaust emission experiments under WLTC, NEDC, and FTP-75 operating conditions, the emission characteristics of exhaust gases under various operating conditions were compared. Through comparative analysis, it is concluded that under WLTC conditions, the strictness of vehicle exhaust emissions has increased compared with the past, which provides a basis for automobile manufacturers to manage vehicle exhaust in the new technical environment.

Keywords: Artificial Intelligence, Light Vehicle, Pollution Emission, Pollution Detection.

1. Introduction

Vehicle exhaust is an important source of urban air pollution in China. The pollution degree of automobile exhaust is not only related to factors such as engine technology and environmental management, but also related to the real driving state of the car. Therefore, it is the key to reduce vehicle exhaust emissions to quantitatively evaluate the variation law of vehicle exhaust under various working conditions, so as to provide a basis for drivers' driving decisions and formulation of traffic control schemes. Currently, emerging pollutant emission simulation methods such as MOVES and IVE are developing towards the micro-scale [1]. The experimental data used in this paper are all measured data on real roads. Compared with the traditional macro-prediction model of vehicle exhaust based on specific working conditions and vehicle speeds, it can better reveal the dynamic characteristics of vehicle exhaust under different working conditions, and then formulate more efficient measures to reduce vehicle exhaust emissions. Since 2001, China has strictly controlled the exhaust emissions of light vehicles. On May 12, 2016, EPA released the draft of "National V", which suggested for the first time that WLTC should be used instead of NEDC for emission testing. Gradually increase the limit value and increase the content of respirable particles (PN). The operating condition of the vehicle is the key to the vehicle exhaust emission performance. In this paper, a number of light vehicles with different configurations and in good condition are selected, and a series of comparative experiments on working conditions are carried out. Through the analysis of the data of the automobile emission experiment, the emission characteristics of pollutants under various working conditions are obtained.

2. Production Mechanism and Hazards of CO And HC in Gasoline Engine Exhaust Gas

2.1. Carbon monoxide

Formed in the absence of sufficient oxygen. Carbon monoxide is a colorless and odorless gas. If it is breathed by humans, it will affect the blood flow of humans, and in severe cases, it will cause life-threatening.

2.2. Hydrocarbons

This phenomenon occurs when the mixture in the air is not fully combusted. The quenching effect of the wall and the unburned mixture adsorbed by the carbon deposit on the wall will be released with the exhaust, which will also lead to an increase in hydrocarbon (HC) emissions. Generally, when the gas concentration is higher, more HC is produced; when the gas concentration is lower, the HC produced is lower [2]. When the gas concentration is too low, HC will rise if there is no ignition. If inhaled HC can cause cancer, HC can also cause photochemical reactions.

3. Fault Diagnosis and Troubleshooting Methods for Excessive CO And HC Emissions

If the measurement is higher than normal, the engine is not operating properly. It can be inspected from the following angles, and correspondingly inspected and analyzed.

3.1. Inspection of fuel feeding device

1) Install a fuel pressure gauge into the oil circuit and check its pressure value. Under no-load conditions, it is generally 250 kPa, and after the throttle valve is opened, it will gradually increase to the maximum open state, about 300 kPa. When the air pressure is high, under the same intake signal, more fuel will be injected from the injection port, resulting in a higher concentration of the mixture. Cause CO, HC

emissions are high. If the fuel pressure can vary as the throttle is opened, but the fuel pressure is always high, then there is a problem with the fuel pressure regulator [3]. If the fuel pressure cannot change with the opening of the throttle valve, the vacuum tube of the fuel pressure adjustment device is broken or dropped, so that the fuel pressure adjustment device does not produce a vacuum.

2) Use the method of auscultation to observe whether the water injection device is working well. When the oil injection machine drips, it will cause the discharge of HCCO to exceed the standard. The fuel injectors should be measured and cleaned.

3) Check the electronic control device of the fuel nozzle. Pay attention to whether the engine fault light on the instrument is flashing, if it is flashing, you can manually read the error code. Just like the manually read error codes in FIG. 1, code 11 is displayed first, and code 31 is displayed next. After the error code is fully displayed, pause for 4.0 seconds and then restart displaying.

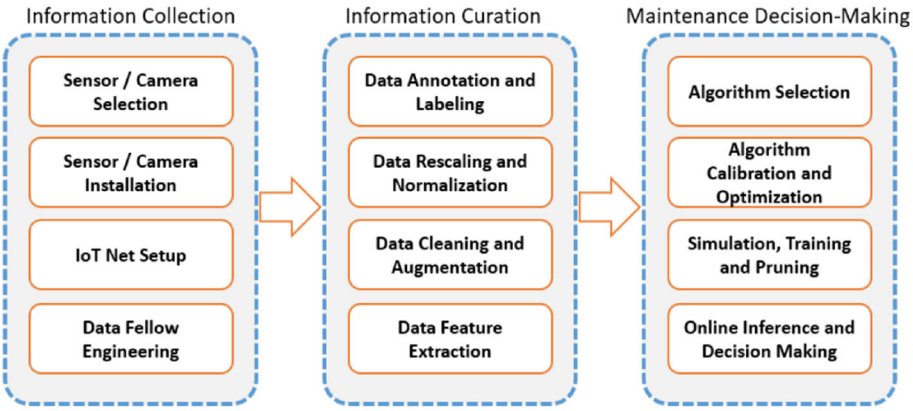

Figure 1. The reading process of manual retrieval of fault codes

4) Check the air-fuel ratio. The closed circuit fuel injection device with three-way catalysis and oxygen sensor makes it have the best mixture ratio of air and fuel (14.7:1). When the three-way catalytic system exceeds the theoretical air-fuel ratio, the activity of the three-way catalytic system will decrease, and the emission of COHC will also increase.

3.2. Calibration of the igniter

1) Check the start timing of the engine. Connect the power plug of the timing gun to the positive and negative poles of the battery. Then use an electric welding needle to fix an electric welding needle on a high voltage electric wire. Start the engine and read the value of the ignition forward tilt angle from the car maintenance manual. If there is deviation, you can rotate the distribution box to adjust.

2) Carry out a shutdown test on a cylinder. Start the engine and unplug the high-voltage wires of each cylinder one by one. If the engine speed does not change, the cylinders are not operating well. Replace a complete high-voltage wire. If the engine runs more stably, it means that there is a problem with the original high-voltage wire. If the engine speed does not change, remove the spark plugs for inspection, clean them, or replace all spark plugs.

3.3. Calibrate the refrigeration system

Due to the poor performance of the cooling system of the diesel engine and the low temperature during operation, the atomization and combustion of the fuel are not complete enough, resulting in the content of CO and HC in the exhaust gas exceeding the standard. A simple way to detect: ask if the temperature regulator of this engine has been disassembled. If it has been removed, reinstall it. If it has not been removed, check the electric fan to see if it can rotate when it is cold. If it rotates when it is cold, the content of CO and HC will exceed the standard [4]. At this time, the plug of the electric heating tube can be unplugged. If the electric heating tube turns off immediately, it means that there is something wrong with the electric heating tube. When the fan continues to spin, there may be a problem with the fan's control wire or relay.

3.4. Testing of cylindrical seals

Due to the wear of the engine cylinder, piston and piston ring, the airtightness of the valve and spark plug is poor, and in the final compression process, the air pressure in the cylinder is not enough, resulting in incomplete combustion of fuel, and the COHC value is too high. The way to check the tightness is: 1) Take off the central high-voltage wire of the distributor, put it in a safe ground, and then take off the harness plug of each cylinder injector; 2) Take out the spark plugs of each cylinder, and install them in order ; 3) Insert the cylinder pressure gauge connector into the flame plug port of the cylinder to be tested and tighten it.

4. Test Findings

4.1. Test device

The experimental vehicles are all light-duty models on sale that meet the National V emission standard. In view of the fact that there are many factors that will affect the results of vehicle emissions, these factors include: vehicle status, equipment conditions, environmental conditions, standard substance factors, driver factors, etc. The same driver was used, the same fuel gasoline was used to ensure that the experimental conditions were stable and the vehicle was in good condition, and the emission test was carried out.

During the test, three different working conditions were used to test the vehicle emissions. Among these operating conditions, the NEDC operating conditions include three parts: constant speed driving, uniform acceleration/deceleration and idling speed driving [5]. However, the WLTC and FTP-75 working conditions have constant changes in vehicle speed and frequent acceleration and deceleration during the entire test cycle, and they are also called transient working conditions. The analysis of working

condition characteristics is shown in Table 1 below.

Table 1. Analysis of working condition characteristics

distinguish	NEDC	WLTC	FTP-75
Travel time/s	1216.49	1855.67	1931.96
Driving distance/km	11.38	23.99	18.32
Maximum speed/(km h^{-1})	123.71	135.36	94.02
Average speed/(km·h^{-1})	34.72	47.98	35.15
Maximum acceleration/(m·s^{-2})	1.07	1.72	1.84
Maximum deceleration/(m s^{-2})	-1.34	-1.55	-1.84
Idle speed ratio/%	25.57	13.61	20.00

4.2. Experimental results

4.2.1. CO emission characteristics

Carbon monoxide (CO) is an intermediate of hydrocarbons in gasoline. In the case of insufficient oxygen, it is easy to cause incomplete combustion of local fuel and produce carbon monoxide (CO). Among the three operation modes of WLTC, NEDC and FTP, the emission of CO is the largest. In the exhaust system, the generation of CO is divided into three stages: start-up open-loop, closed-loop heat engine, rapid acceleration transient and high-speed operation [6]. Through the analysis of the CO transient emission data under different conditions in Figure 2, it can be seen that the peak of CO emission under the three conditions appears in the cold start stage, which is caused by the enrichment of the engine's cold start fuel (Fig. Cited in Energies 2020, 13(16), 4245). Compared with other operating modes, the low temperature start and high speed during WLTC operation are important factors leading to a significant increase in CO emissions. Under FTP operating conditions, although the CO concentration during FTP operation is higher than that of NEDC, its calculation method is quite different from that of WLTC such as WLTC and NEDC, and because the CO concentration in FTP operation is small, So the final value is smaller than the NEDC runtime.

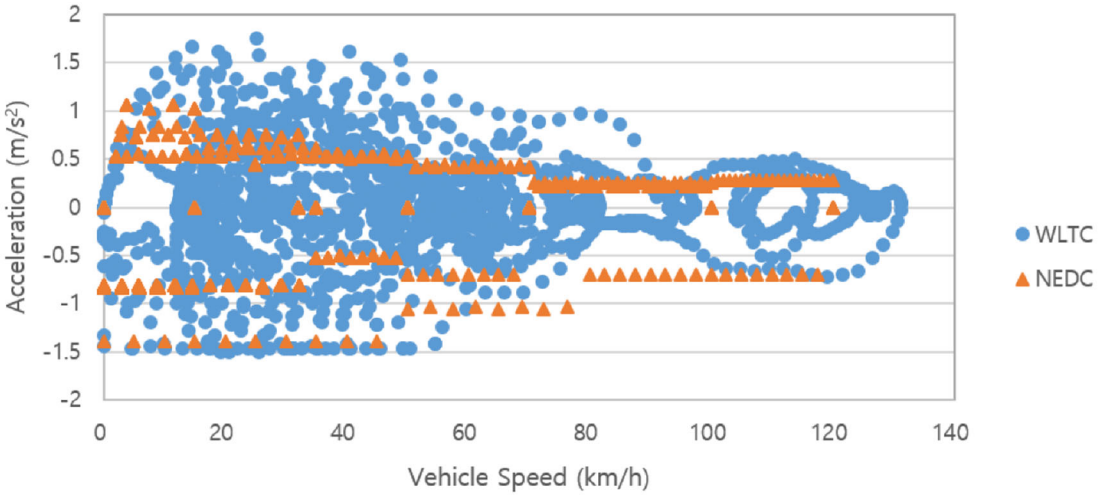

Figure 2. Instantaneous release of CO under various conditions

4.2.2. Hydrocarbon release characteristics

There are many reasons for HC in the exhaust gas, such as chilling and incomplete combustion in the cylinder. Compared with NEDC mode, HC emissions are reduced by 20% in WLTC mode and 50% in FTP mode. In the process of exhaust emission, the generation of HC is concentrated in the start-up, open-loop, and warm-up cycles, and also in the higher speed range [7]. The instantaneous HC emission data in each state shown in Fig. 3 shows that the HC emission in state 3 is relatively high when the engine is not fully warmed up at the start of the cold state, and the emission peak values in the FTP-75 state and WLTC state are similar, but both are higher than NEDC status is high. Under the condition of WLTC, a small amount of HC will still be produced at high speed. At this time, due to the sudden acceleration of the engine and the increase of fuel injection, the HC rises. However, due to the limitation of the oxygen storage capacity of the catalyst, the HC cannot be completely released, and the HC intensifies. Although the instantaneous emission of NEDC is not the largest, its full-load working mileage is twice that of WLTC, making the emission value in km the largest, while FTP uses the calculation method of weight coefficient to make its emission value in km the smallest (The picture is cited in Energies 2017, 10(2), 240).

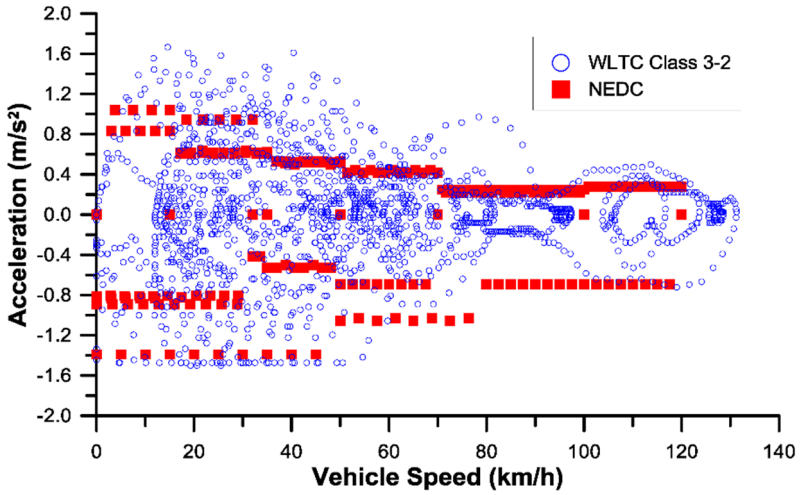

Figure 3. Instantaneous release of HC under various conditions

4.2.3. Release characteristics of nitrogen oxides

NOx refers to the general name of nitrogen oxides such as NO, NO2, N2O, N2O3, etc. The mechanism of its formation is mainly high temperature, oxygen enrichment and sufficient reaction time. NOx emission is the least under NEDC mode, NOx emission under FTP mode is 120% higher than NEDC mode, WLTC mode is 180% higher. In the process of exhaust gas circulation, the generation of NOx is mainly transient, transient and high speed [8]. The NOx instantaneous emission data shown in Figure 4 shows that the NOx concentration of the car is relatively high during the fast and fast driving of the car (the picture is quoted in Energies 2017, 10(2), 240). NEDC operates in a steady state, with a total of 16 accelerations and 18 decelerations, all of which are uniform accelerations and decelerations, with minimal NOx emissions. Since the two operating modes of WLTC and FTP-75 are transitional modes, the frequency of speed fluctuations is relatively fast and uneven, so that the NOx emissions in the two operating modes are significantly increased compared with NEDC. Because the average vehicle speed and the maximum acceleration/deceleration ratio of FTP are higher during WLTC operation, resulting in high NOx emissions during WLTC operation, which is the key to its response to the new regulations.

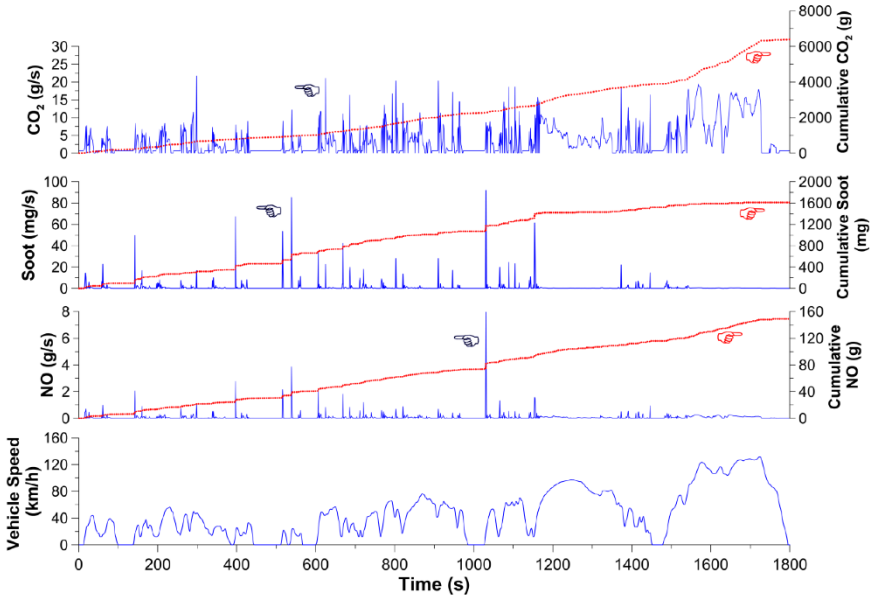

Figure 4. Instantaneous release of NOx under various operating conditions

5. Conclusion

1) Under WLTC operating conditions, the frequency of vehicle speed fluctuations is large, and the average vehicle speed is large, and the emissions of CO and NOx are also large; 2) Under FTP operating conditions, the instantaneous emissions of various pollutants are large, but at the end In terms of the value of , due to the use of different weight calculation methods, no good results have been obtained. 3) NEDC operates in a steady state, and its pollution degree is relatively small, mainly when the cold engine is started, but the running distance is very short, so the emission of HC is also large. Therefore, the use of WLTC working conditions will impose stricter requirements on the pollutant emission control of automobiles, and automobile manufacturers need to make corresponding adjustments to adapt to the new standards.

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