ISSN: 2664-9640

Energy saving and emission reduction, green travel

-- innovative design of tunnel carbon reduction device for transportation carbon emission

Shenchao Cao, Yi Chen, Huiling Hu, Qiushuang Dong

Anhui University of Finance and Economics, Bengbu City, Anhui Province, 233000, China

Abstract

With the rapid economic growth in China, great achievements have been made in various construction projects, but huge costs have been paid for the destruction of resources and environment. The contradiction between the two has become increasingly acute. The public has a strong reaction to environmental pollution, which is also reflected in the transportation industry.At the same time, greenhouse gas emissions cause global warming, which has been widely concerned by the international community. Further strengthening energy conservation and emission reduction is also an urgent need to deal with global climate change.If you want to improve the transportation equipment, it will cause a lot of pollution to the environment, which will lead to excessive emissions of transportation equipment.The tunnel carbon reduction device proposed in this paper actively explores the establishment of a new mode of transportation development characterized by high energy efficiency, low energy consumption, low pollution and low emission, so as to reduce carbon emission and save energy for agricultural production, continuously improve the quality and level of development, turn waste into treasure, and realize transportation saving, green and sustainable development.In order to solve the problem of carbon emission by using high-tech, build a low-carbon environmental protection transportation system, and achieve the purpose of energy-saving, emission reduction and green travel.

Keywords

Smart transportation;Green travel;Carbon reduction in tunnels;conserve energy ,reduce emissions.

1. Project plane

1.1. Current situation and research background of traffic carbon emission in China

At present, transportation emissions account for about 10.4% of China's total carbon emissions, especially road transport, which accounts for more than 85% of the total carbon emissions of transportation in China, which is the absolute main body and emission reduction focus of transportation carbon emissions. In the near future, as China's national economy and transportation will continue to grow rapidly, the technical level and energy structure of transportation development have not fundamentally changed, and the total carbon emission in the field of transportation will continue to increase. The pressure of emission reduction is great and the situation is grim.

1.2. Research objectives and main contents

Research objectives

ISSN: 2664-9640

In this paper, collaborative research, the use of high-tech to solve the problem of carbon emissions, to build a low-carbon environmental protection of the new transportation system.The principle of gas conversion instrument is used to realize the recycling of gas resources. The converted gas is used as fertilizer to reduce the production cost of crops, save resources and turn waste into treasure. It is expected to be widely used in the field of transportation and play an auxiliary role in agricultural production and development. The new transportation mode with high energy efficiency, low energy consumption, low pollution and low emission is actively studied and explored.

primary coverage

Based on the working principle of the reformer, a formula model for calculating the conversion efficiency of the reformer was constructed. The parameters in the model were estimated and the results were verified by collecting historical data, and the dynamic model of the calculation formula was obtained. By comparing the parameter results of the dynamic model with the inherent calculation model of the analyzer, the optimal and appropriate CO_2concentration of crops was calculated,It can be used to maximize the photosynthesis of crops. It can improve the growth rate of plants, reduce the negative impact of excessive carbon emission on the environment, and improve the adaptation and regulation of crops to the environment. The nitrogen oxides in the tail gas can be converted into favorable gas through the nitrogen oxide conversion instrument, and then transported to the botanical garden or vegetable greenhouse to turn waste into treasure and realize the recycling of resources.Tunnel carbon reduction device focuses on the recovery and utilization of resources through the principle of tail gas converter.

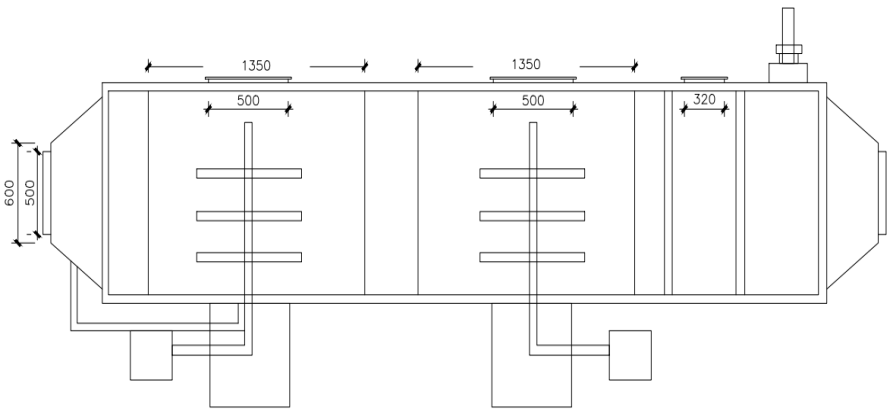

Figure 1 design of tunnel carbon reduction device

1.3. Innovation and project characteristics

Integration of various gas treatment technologies

Compared with the traditional combustion method and other methods, the tunnel carbon reduction device is based on the principle of gas convertor and combined with a variety of gas treatment technologies to convert the tail gas into ammonia, carbon dioxide and other favorable gases, which are transported to the botanical garden or vegetable greenhouse by pipeline to act as fertilizer for crops, which is conducive to the growth and results of plants.It not only solves the problem of emission pollution at will, but also benefits the development of plant economy and reduces the cost of chemical fertilizer for plant growth.

ISSN: 2664-9640

2. Innovation points and project characteristics

2.1. Electronic control technology of catalytic oxidation reduction

The principle of three-way catalytic conversion is to use the chemical characteristics of the components of exhaust gas to promote the reaction.In the three kinds of harmful gases, HC and CO have strong reducibility, while NOx has certain oxidizability. Under the action of catalyst, the three kinds of redox reactions can take place, so that HC and Co are oxidized to h_2O and CO_2, and NOx is reduced to n_2.The chemical reaction equation is as follows:

oxidation reaction $2CO + O_2 = 2CO_2$

$$CO + H_2O = 2CO_2 + H_2$$

$$2C_XH_Y + \left(\frac{2x+1}{2y}\right) O_2 = yH_2O + 2xCO_2$$

Reduction reaction $2NO + 2CO = 2CO_2 + N_2$

$$2NO + 2H_2 = 2H_2O + N_2$$

$$C_xH_y + \left(\frac{2x+1}{2y}\right) NO = \frac{1}{2y}H_2O + xCO_2 + \left(\frac{2x+1}{4y}\right) N_2$$

It can be seen from the above reactions that the reduction of NOx requires Co, H2 and HC as reducing agents. If there is excessive oxygen in the exhaust gas, these reducing agents react with oxygen first, then the NOx reduction reaction can not be carried out.However, CO and HC can not be completely oxidized if the air is insufficient, that is, the oxygen concentration is insufficient.

2.2. Activated carbon adsorption method for tail gas treatment:

Activated carbon is used to adsorb odorous substances in the polluted gas. The polluted gas passes through the activated carbon layer, and the pollutants are adsorbed, and the clean gas is discharged from the adsorption tower.At the top of the tunnel, activated carbon is used to filter the tail gas, which is converted into favorable gas through the nitrogen oxide conversion device in the pipeline and transported to the greenhouse for photosynthesis.By paying attention to various factors that affect the adsorption effect, under the condition of increasing the atmospheric pressure, it is possible to form a good adsorption pressure difference between the activated carbon and the automobile exhaust gas, as well as control the operating conditions, control the temperature and pressure of the tail gas to be adsorbed and the actual speed generated by the relative air flow, so as to realize the application of the activated carbon adsorption method.

2.3. Automobile exhaust conversion technology

$$2CO + 2NO = 2CO_2 + N_2$$

$$2xCO + 2NO_x = 2xCO_2 + N_2$$

Impact on crops:

$$6CO_2 + 6H_2O = C_6H_{12}O_6(\text{starch}) + 6O_2$$

$$\text{Carbon dioxide} + \text{water} \xrightarrow{\text{light}} \text{organic compound(Energy storage)} + \text{Oxygen}$$

Carbon dioxide is the raw material of light and action. Carbon dioxide fertilization can promote the light and effect of plants and improve the efficiency of photosynthesisHowever, when the concentration of carbon dioxide reaches a certain value, the photosynthetic efficiency of plants reaches saturation, and no longer increases with the increase of carbon dioxide concentration

ISSN: 2664-9640

$$N_2 + O_2 \xrightarrow{lightning} 2NO$$

$$2\mathrm{NO} + \mathrm{O}_2 = 2\mathrm{NO}_2$$

$$3\mathrm{NO}_2 + \mathrm{H}_2\mathrm{O} = 2\mathrm{HNO}_3 + \mathrm{NO}$$

Soil absorbs nitrate to form nitrate

$$N_2 + 3H_2 \xrightarrow{High\ temperature,high\ pressure,catalyst} 2NH_3$$

$$4NH_3 + 5O_2 \xrightarrow{Catalyst,heating} 4NO + 6H_2O$$

$$2NO + O_2 = 2NO_2$$

$$3NO_2 + H_2O = 2HNO_3 + NO$$

2.4. Road condition detection system installed inside the device

The real-time monitoring of the traffic section is carried out by running the road condition detection system set in the tunnel carbon reduction device. When the vehicle encounters a traffic accident and the exhaust pollution is aggravated, the road condition detection system will automatically judge and send a distress request to the server, and timely transform the nitrogen oxides in the exhaust gas into favorable gases through the nitrogen oxide conversion instrument in the pipeline,Transport to the botanical garden or vegetable greenhouse to realize the recycling of waste resources.

Based on the real-time data of acceleration sensor and gravity sensor, the system adopts a variety of self-developed accident identification algorithms, calculates and compares the accident warning threshold to carry out the hazard parameter analysis.The acceleration can be detected to determine whether the vehicle is in collision, and whether the vehicle rollover occurs through the horizontal tilt angle;When the vehicle encounters traffic accidents, road congestion and other situations, the system will obtain the location information of the accident vehicle at the first time, automatically judge and send the road condition report to the server. Through the server, it will remind the vehicles to change the best route, avoid the traffic congestion, reduce the driving distance, and further reduce the fuel consumption and pollution.

3. Technical route, problems to be solved and expected results

3.1. Technology roadmap

Related principle: NOx converter principle and analyzer detection technology

In the traditional nitrogen dioxide conversion furnace, molybdenum is used as catalyst, and the reaction principle is shown in (1)

$$2NO_2 \xrightarrow{\text{Catalyst,high temperature}} 2NO + O_2 \tag{1}$$

ISSN: 2664-9640

Figure 2 three dimensional design of tunnel carbon reduction device

3.2. Technical route and proposed solution

SCR denitration

Selective catalytic reduction (i.e. in SCR denitrification process, ammonia can be added toNO_xIt is converted into nitrogen which is naturally contained in the air (N_2) And water (H_2O) The main chemical reactions are as follows:

$$4NO + 4NH_3 + O_2 \xrightarrow{\text{Catalyst,high temperature}} 4N_2 + 6H_2O$$

$$6NO + 4NH_3 \xrightarrow{\text{Catalyst,high temperature}} 5N_2 + 6H_2O$$

$$6NO_2 + 8NH_3 \xrightarrow{\text{Catalyst,high temperature}} 4N_2 + 12H_2O$$

$$6NO_2 + 4NH_3 + O_2 \xrightarrow{\text{Catalyst,high temperature}} 3N_2 + 6H_2O$$

In the absence of catalyst, the above chemical reactions only take place in a very narrow temperature range (850 ~ 1100 ℃), and the activation energy of the reaction is reduced by using catalyst, which can be carried out at a lower temperature (300 ~ 400 ℃).Selectivity refers to the effect of catalyst and the presence of oxygen,NH_3Priority andNO_xReduction reaction occurs instead of oxidation reaction with oxygen in flue gas.SCR system at home and abroad mostly use high temperature catalyst, reaction temperature is 315 ~ 400 ℃.

Model building

In practical work, the working flow of NOx conversion instrument is shown in Fig. 4.

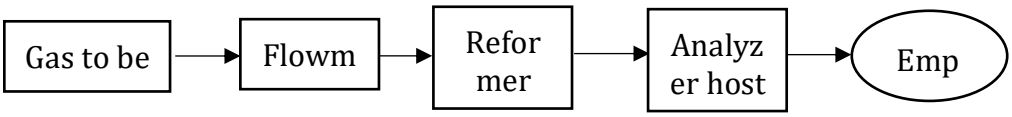

Fig. 3 work flow of NOx convertor

The measured gas is carried out through the reformerNO_2After the reduction reaction, it enters the analyzer for detectionNOThe concentration of.However, in the process of conversion, the activity of catalyst, the concentration of standard gas and the stability of equipment may affect the efficiency of conversion.Based on the above factors, it is proposed thatNO_2The formula is shown in (2)

ISSN: 2664-9640

$$x = \frac{C_1 - C_0}{C_0} \times 100\% \quad (2)$$

Among them, x express NO_2 The conversion error of; C_1 express NO_2 Gas concentration after conversion; C_0 express NO_2 Gas concentration before conversion.

Gas detected in analyzer host NO At the concentration, the detection results are also related to many factors, such as the temperature change, the purity of zero gas and the influence of impurities in the gas, which will bring errors to the analyzer detection junction.Considering these factors comprehensively, the paper proposes that NO The calculation formula is shown in (3).

$$y = \frac{D_1 - D_0}{D_0} \times 100\% \quad (3)$$

Where y is the NO Detection error of gas concentration; D_1 It indicates that the NO Gas concentration value; D_0 Represents the gas before detection NO Concentration value.According to the working principle of the analyzer, it is known that the conversion efficiency of the reformer is affected by NO_2 Sum of transformation errors NO The interference of two factors of detection error.Therefore, a mathematical model related to both can be proposed, and the parameters in the model can be estimated by the actual data collected.The calculation formula of the model is shown in (4).

$$\varphi = a + b * x + c * y \quad (4)$$

Among them, φ Represents the conversion efficiency of the reformer; x express NO_2 The conversion error of; y express NO Detection error of gas concentration.

Parameter determination

In order to ensure the authenticity and reliability of the experimental data, the first class standard gas of China Institute of testing technology was selected in the experiment, and its nominal concentration value was taken as the gas concentration value before detection and conversion. The specific information is shown in Table 1 (the unit of gas concentration value is 10 ~ 6 mol / mol).

form 1Determination of standard gas information

Standard gas	Gas standard concentration	Relative expanded uncertainty of indication
$\boldsymbol{NO}$	$D_0 = 300$	$U_{rel} = 1.5\%(k = 2)$
$\boldsymbol{NO_2}$	$C_0 = 300$	$U_{rel} = 2\%(k = 2)$

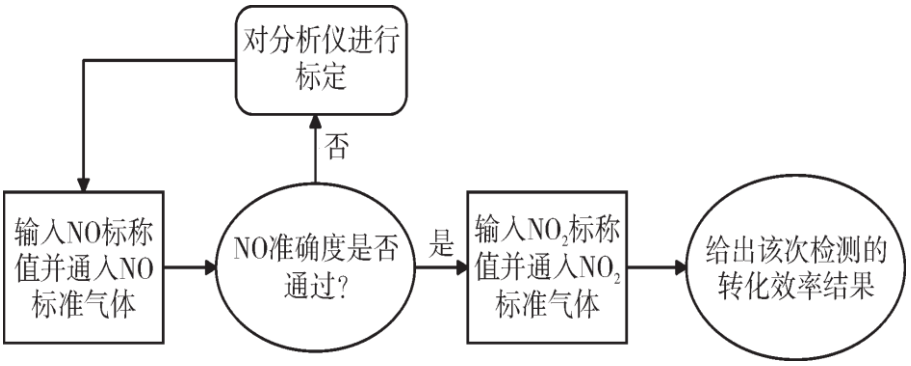

Fig. 4 detection process of analyzer

The detection results of conversion efficiency are as follows:

ISSN: 2664-9640

form 2Conversion efficiency detector

Number of groups	Instrument 1	Instrument 2	Instrument 3
1	93.60	96.80	95.10
2	93.30	96.40	94.30
3	92.70	95.70	94.40
4	94.00	96.20	94.90
5	93.10	97.10	95.70
6	94.10	96.30	94.70
7	93.00	96.10	95.70
8	93.70	96.00	94.90
9	92.60	96.30	94.60
10	92.70	96.30	95.10

Parameter estimation

In order to determine the parameters a, B and C, regression analysis was carried out on the data of each convertor and all the data at 95% confidence level. The fitting results are as follows:

form 3Fitting results

Equipment number	a	b	c
1	1.003	1.024	-.949
2	.999	1.030	-1.124
3	1.002	1.036	-.997
All data	1.001	1.015	-1.013

Validation of estimation results

$$\varphi^* = 1 + x - y \tag{5}$$

amongφ^*It represents the inherent conversion efficiency calculation model of the convertor.

In order to compare the goodness of fit between the estimated parameters in Table 3 and the parameters in equation (5), the test results of the three convertors are calculated into the data$x$and$y$The calculation results are recorded as$\varphi^*{}_i$(iThe regression model of the conversion

ISSN: 2664-9640

efficiency test results in Table 2 was established SSE^* and R^{2^*} The calculation formula is as follows:

$$SSE^* = \sum_{i=1}^{n} (\varphi_i{}^* - \hat{\varphi})^2$$

$$SST^* = \sum_{i=1}^{n} (\varphi_i{}^* - \overline{\varphi_i{}^*})^2$$

$$R^{2^*} = 1 - \frac{SSE^*}{SST^*}$$

Take a, B and C from table 3 into (4), and the calculation results are as follows φ_i (among them, i This is the number of times $\varphi_i{}^*$ The regression model was also calculated SSE and R^2 The formula is as follows:

$$SSE = \sum_{i=1}^{n} (\varphi_i - \varphi_i{}^*)^2$$

$$SST = \sum_{i=1}^{n} (\varphi_i - \overline{\varphi_i})^2$$

$$R^2 = 1 - \frac{SSE}{SST}$$

Where, the sum of squares of residuals (SSE and SSE^*) The closer to 0, the multiple determinable coefficient (R^2 and R^{2^*}) The closer to 1, the better the model fits the data.The results of twice fitting are shown in Table 4.

form 4Twice fitting results

Equipment number	SSE^*	R^{2^*}	SSE	R^2
1	$7.778e^{-6}$	.9714	$3.707e^{-7}$	.9985
2	$6.444e^{-6}$	.9538	$7.277e^{-7}$	.9940
3	$5.333e^{-6}$	.9744	$8.284e^{-7}$	.9958
All data	$1.956e^{-5}$	.9963	$2.243e^{-6}$	.9996

4. Problem to be solved

Facing the national "carbon neutral" strategic requirements, it can be applied to a variety of scenarios, such as highway sections with huge traffic flow, urban main trunk lines, urban suburbs with more factories, scenic spots with too many self driving modes, reducing the

pollution caused by high emission of traffic and transportation exhaust, and building a new transportation system with low carbon and environmental protection.

Using the principle of gas conversion instrument to realize the recycling of gas resources, turning waste into treasure, making gas fertilizer to reduce the production cost of crops, green environmental protection and resource saving.

The real-time monitoring of the traffic section is carried out by running the road condition detection system set inside the tunnel. When the vehicle encounters traffic accidents, traffic jams and other situations, the system will automatically judge and send the road condition report to the server. Through the server, the vehicle will be reminded to change the best route, so as to avoid vehicle congestion, reduce the driving distance and further reduce the fuel consumption and pollution,Realize green travel.

5. Expected results

Based on the working principle of the converter and combined with various tail gas treatment technologies, the tunnel carbon reduction device aims to achieve high-efficiency emission reduction, reduce environmental pollution, significantly accelerate the formation of green and low-carbon transportation mode, increase the proportion of green and low-carbon transportation mode, increase the coordination of comprehensive transportation system, and establish a high-efficiency, low-energy consumption, low-pollution, low-carbon transportation modeA new mode of transportation development characterized by low emission.We hope to carry out feasibility study around the innovative ideas, let intelligent design realize the green transformation of transportation industry, improve the quality and level of development, realize the economical, green and sustainable development of transportation, and provide reference value for the development of China's transportation field.

References

[1] Zhan BinbinConversion efficiency modeling and parameter estimation of NOx analyzerSoftware guide, 2020.
[2] Dai XiaofengResearch on exhaust emission control strategy of three-way catalytic converter Automobile and safety, 2018.
[3] Zhan BinbinStatistical calculation method of conversion efficiency of NOx analyzerMeasurement technology, 2021.
[4] He fanPolicy analysis of continuous regeneration characteristics of particulate filter under road cycle conditionsVehicle and power technology, 2021.
[5] Dai XiaofengThree way catalytic converter and vehicle exhaust emission control strategy researchAutomobile and safety, 2018.