Energy self-supply automobile exhaust gas circulation processing device

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Abstract. Aiming at the energy waste caused by the exhaust emission of about 30\%–40\% of the automobile engine energy and the exhaust emission caused by the failure of the three-way catalytic converter to reach the working temperature during the start-up of the automobile, our team proposes a design scheme for energy reuse and exhaust gas treatment of automobile exhaust pipes. The work has the characteristics of simple structure, low cost and strong pertinence, and achieves energy conservation and reduction of air pollution caused by exhaust emissions. The main body of this work consists of an energy conversion system and an exhaust gas circulatory system. Energy conversion system: The heat of the exhaust cylinder wall is reused by the thermoelectric power generation sheet. In order to convert thermal energy into electrical energy with higher efficiency, a heat sink is used to increase the temperature difference between the inside and outside of the thermoelectric power generation chip. The secondary energy utilization can realize the autonomous operation of the exhaust gas circulation system. Exhaust gas circulation system: The system is automatically controlled by single-chip microcomputer STM32F10XX. When the vehicle starts, the automobile exhaust gas would not meet the emission standard. At this time, the exhaust gas is passed into the exhaust gas storage bag, and the temperature of the three-way catalytic converter is monitored by the temperature sensor. When the operating temperature of the three-way catalytic converter is reached, the exhaust passage will be converted by the single-chip microcomputer, and the automobile exhaust gas will be discharged into the air. At the same time, the non-standard exhaust gas in the exhaust gas storage bag is again introduced into the three-way catalytic converter for secondary catalysis by using a micro-extractor. This avoids the situation that the temperature of the three-way catalyst is low and the catalytic efficiency is low, resulting in substandard exhaust emissions.
1. Introduction
At present, there is almost no waste heat reuse exhaust pipe in the domestic market. However, due to the sustained and rapid development of China's economy and society, the proportion of automobiles has increased year by year and has become the main body of motor vehicles. However, only 38.5% of the heat generated by the automobile engine is used as the power output. There is still about 33% of the thermal energy discharged into the air with the exhaust gas [1]. This incidental energy loss cannot be underestimated, which is especially important for the utilization of the exhaust pipe heat energy. This has led many scholars to conduct in-depth research on the reuse of vehicle exhaust heat, providing a strong theoretical support for the reuse of vehicle exhaust heat. However, this type of exhaust pipe has not been popularized. The main reason is that the function is single, and the temperature difference power generation chip cannot guarantee efficient use and lacks universality. The commonly used purification technologies are mainly divided into two categories: internal purification and external purification. 1) In-machine purification: It is achieved by improving the structure and combustion conditions of the internal combustion engine of the automobile. Such as the improvement of carburetor, ignition system and combustion system [2], electronically control gasoline injection; accelerate the promotion of scientific research results, improve the penetration rate of clean and pollution-free fuel. In-machine purification technology can only reduce the amount of harmful gases generated. In order to achieve a more stringent emission standard for vehicle exhaust emissions, it is necessary to convert the vehicle exhaust into a harmless gas by means of a catalytic converter before it is discharged to the atmosphere. 2) Off-machine purification: The research is mainly focused on catalytic purification, and the catalyst is the key to the purification effect. Therefore, scientists have made the improvement of catalysts and the choice of carriers as the research focus. At present, the main domestic external purification device is a three-way catalytic converter, but the three-way catalytic converter starts its action at a temperature of 200 degrees and the optimum working state is at 200-400 degrees. When the car starts, the three-way catalytic converter can not reach the proper working temperature [3]. At this time, the exhaust gas that is discharged does not meet the standard, causing environmental pollution, and there are certain defects.

2. Scheme design
2.1. System Composition and Principle
As is shown in the schematic diagram of the device structure of Fig. 1, the device is composed of an electromagnetic valve, an insulated airbag, a gas pressure sensor, an ultrasonic sensor, a thermoelectric power generation chip, a miniature vehicle air pump, a temperature sensor, a single chip microcomputer, and a battery. The gas pressure sensor and the temperature sensor are connected to the single chip microcomputer to realize the detection of the temperature of the three-way catalyst and the protection of the heat insulating airbag. The thermoelectric power generation chip is connected with the battery, the electromagnetic valve, the micro-vehicle air pump, and the single-chip microcomputer to provide power supply for the system. The single-chip microcomputer is connected with the micro air pump and the electromagnetic valve to realize the control of the device[4].
Fig. 2 is a schematic view showing the three-dimensional structure of the thermoelectric power generation part, which adopts a relatively common tubular type thermoelectric power generation structure. The heat sink is added to increase the temperature difference between the two faces of the thermoelectric sheet [4].

2.2. Device workflow introduction
The device is activated when it is determined that no debris is stored in the trunk. At this time, the gate No. 3 is opened and the gate No. 10 is closed. The non-standard exhaust gas is discharged into the exhaust gas storage airbag. When the temperature sensor detects that the three-way catalytic converter reaches the working temperature, the No. 10 valve will be opened by the single-chip microcomputer, the exhaust gas will be discharged into the air, the third valve will be closed, and the micro-vehicle air pump starts to work and will be stored before. The non-standard exhaust gas is passed through a three-way catalytic converter for secondary treatment to complete the entire process. The gas pressure sensor acts as a protection device to prevent excessive gas from causing the airbag to explode or the exhaust cylinder to become clogged. When the gas pressure sensor detects that it is in danger, the working process when the temperature sensor reaches the operating temperature of the three-way catalytic converter will be directly executed, and the gas will be discharged. The whole set of equipment operation process is very simple, basically realizes automatic operation, there is no difficult principle, and the quality of the operator is not high, suitable for the use of various models.
2.3. Implementation process
The installation of the whole set of equipment has the characteristics of low power consumption and simple structure, and can be connected according to the principle plan of Fig. 1. The gas pressure sensor 2, temperature sensor 3, electromagnetic valve 4, micro-extractor ultrasonic sensor is connected with the single-chip microcomputer STM32F10XX to realize the control and automation of the four electronic devices by the single-chip microcomputer. 7 power storage device 8, single-chip 9 temperature difference power generation chip according to the schematic diagram to connect, thus achieving the device to operate independently. Connect the exhaust passage as shown in the figure. The whole set of equipment is simple in structure, convenient to install, has little change to the original automobile device, and realizes exhaust gas emission, and has high practical value. FIG. 3 is a physical map of the work model.

![Figure 3. Model object](image)

3. Innovation and characteristics
The device solves the energy waste caused by exhaust gas emissions of about 30%~40% of the automobile engine and the failure of the three-way catalytic converter to reach the activation temperature when the vehicle starts, causing the pollutant discharge to account for 20%~40% of the total discharge. The problem.

Using the trunk when vacant, creatively use the electromagnetic valve to change the gas flow direction before the car is ignited, and store it with an insulated storage airbag in the trunk until the three-way catalytic converter reaches the activation temperature. When the electromagnetic valve of the pipeline is closed and the electromagnetic valve of the tail pipe is opened, the gas in the airbag is again pumped into the exhaust pipe by a small air extractor, and then enters a three-way catalytic converter for catalytic reaction. Reduce emissions of large amounts of pollutants. The transformation part is mainly at the end of the exhaust pipe, which reduces the danger caused by high temperature, improves the safety of the device, and takes into account the use of the user's trunk. The ultrasonic sensor is used to detect the object piled up in the trunk, and the space occupied by the object. When the 3/4 of the trunk volume is exceeded, the device will not be activated, and the exhaust gas will be directly discharged. The device will not start up, and the device can be automatically started and stopped according to the situation.

The two solenoid valves are connected by an inverter to ensure that the two valves do not work at the same time. Avoid obstruction of the exhaust pipe due to work failure.
The structure and the basic principle thereof are simple and easy to implement. Compared with the scheme of preheating the catalyst, the cost of the device is low and the energy consumption is low, and the realization value is high.

4. Conclusion
Through the energy conversion system composed of the Seebeck effect, the waste heat of the exhaust gas is reused; The exhaust gas circulation system solves the problem that the temperature of the three-way catalyst is low when the automobile starts, and the catalytic efficiency is low, and the exhaust gas treatment standard cannot be reached. This work not only achieves energy conservation but also reduces emissions, and it is based on real problems. It has strong pertinence, clear application direction, simple structure, easy implementation and low cost, so it is highly feasible and will have a very good application effect.

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