The Study of Exhaust Gas Recycling(EGR) System

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***Abstract*— In this paper, we introduced and analyzed automobile engine's common linear exhaust gas recirculation system's features ,with a method of comparison, based on my years of vocational colleges' Automotive Electronic Control Engine Construction and Maintenance teaching practices. Among these includes the structural characteristics and the working principle of linear exhaust gas recirculation valve and the characteristics of the control circuitAppropriate methods and exclude some troubleshooting methods and so on. This paper will be a reference to the study and research of automotive emission control systems as well as in automotive emission control systems maintenance and fault diagnosis work.**

Keywords- Engine ; EGR ; emission control.; Exhaust gas recirculation; Linear control

I.INTRODUCTION

Automotive engine emission control system includes crankcase ventilation system (PCV), exhaust gas recirculation system (EGR), fuel evaporative emission control system (EVAP) and a three-way catalytic converter system (CAT) [1].The linear exhaust gas recirculation system has obvious characteristics compared with other exhaust gas recirculation systems. Only by understanding its characteristics, can it be more convenient for automotive emission control systems' learning and research and be a specific guidance to the maintenance and fault diagnosis work of vehicle emission control system.

II.ANALYSIS OF EXHAUST GAS RECIRCULATION SYSTEM

Exhaust gas recirculation system, also known as EGR system, which is commonly used in a car to reduce the harmful gases of nitrogen oxides (NOx) [2]. The basic working principle is: during engine operation, a small amount of complete combustion exhaust was introduced into the intake manifold through the exhaust gas recirculation system and mixed with the fresh air and participates in the combustion in the cylinder. Thereby it can reduce the maximum combustion temperature and reduce the emission of nitrogen oxides (NOx). Many car companies' engine exhaust gas recirculation system control the opening of exhaust gas recirculation valve (also known as the EGR valve) throgh the vacuum suction of engine intake manifold and the tension of diaphragm spring[3] .Thus control the quantity of relux of exhaust gas .Working principle of the system is shown in Figure 1.

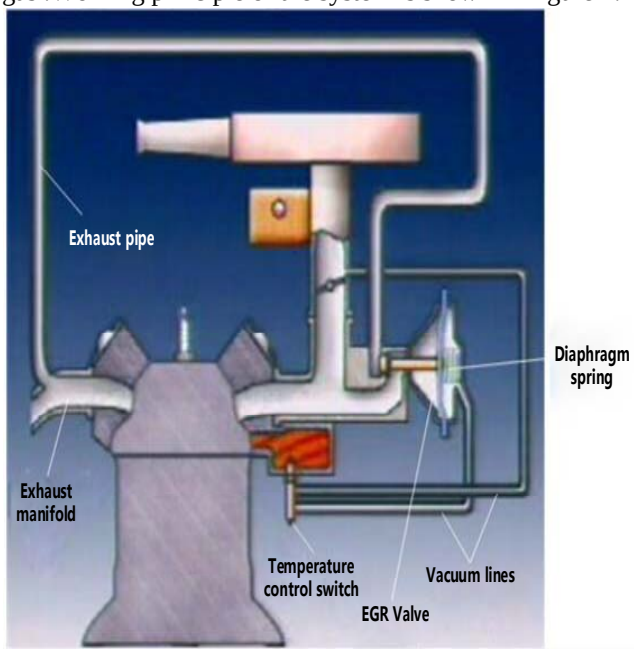

Figure 1: Exhaust gas recirculation system schematic diagram

The working principle is: When the temperature of the engine coolant reaches a predetermined value, the thermostat switches the vacuum hose connected, the vacuum suction from the side of throttle transmitted through the vacuum line to the right of the EGR valve diaphragm, and overcome the leftward thrust of diaphragm spring, pull rightward the valve stem and valve that fixed on the diaphragm seat, a portion of exhaust in the exhaust manifold flow into the intake manifold through the exhaust pipe and the opened EGR valve, and mixed with the fresh

air from the air filter ,flow into the cylinder and been burned [4].

Obviously, in the above-mentioned working principle, the opening of EGR valve is only controlled by a single factor ,which is the engine coolant temperature, and the opening degree of the EGR valve cannot be precisely controlled, so that the effect of reducing the nitrogen oxide (NOx) emission is not very good.

III. Working Principle of Exhaust Gas Recirculation System

With the development of automotive technologies and emission regulations become more stringent, some car companies improved the above-mentioned exhaust gas recirculation system. It's a " electronically controlled EGR control system with EGR position sensor", it works as shown in Figure 2.

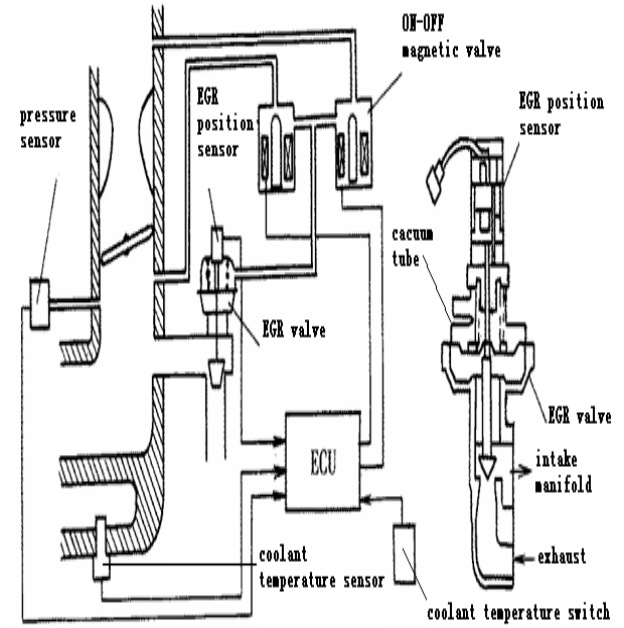

Figure 2 Electronically controlled EGR control system with EGR position sensor

EGR valve position sensor mounted on the top EGR valve is used for detecting the EGR valve lift (i.e. the valve opening) and converting the EGR valve opening to an electrical signal input in ECU, as a reference signal for the ECU control the exhaust gas recirculation[5]. The system according to the engine load and speed, pre-set the EGR valve lift position , and control the negative pressure of EGR valve diaphragm chamber by changing the state of the ON-OFF magnetic valve [6].In the course of work, the system compared the predetermined EGR valve lift with the current position of the EGR valve, if not equal, the ECU controls the ON-OFF magnetic valve to change the operating state, the EGR valve lift is adjusted to the optimum value.

In a common automotive engine's exhaust gas recirculation system, using a linear exhaust gas recirculation valve (i.e. EGR valve). The engine control module (ECM) can control linear exhaust gas recirculation valve opening precisely based on the throttle position sensor signal and the intake pressure sensor signal [7]. Meanwhile, the engine control module (ECM) can monitor the actual opening of the valve at any time to see whether it meets the requirement according to the linear exhaust gas recirculation valve feedback signal. The structure of linear exhaust gas recirculation valve is shown in Figure 3.

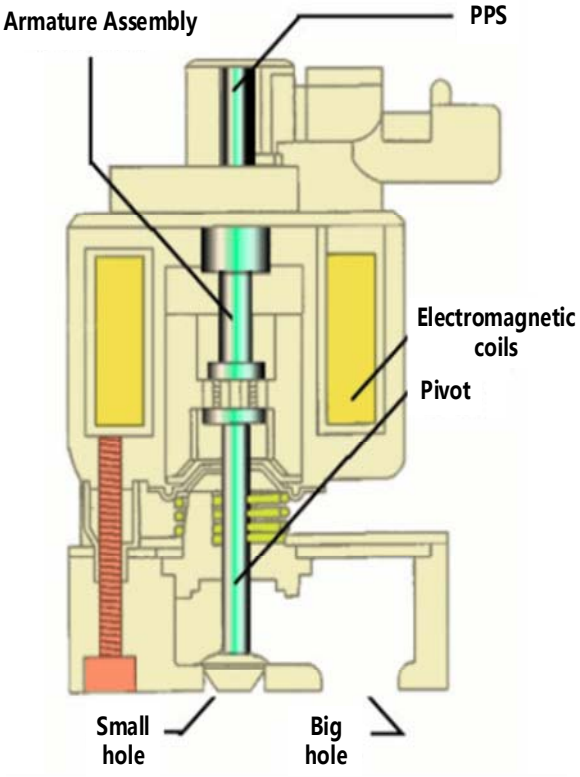

Figure 3 The structure of linear exhaust gas recirculation valve

IV. Linear Exhaust Gas Recirculation

Linear exhaust gas recirculation valve control the upper and lower position of the pivot and valve using the pivot upward electromagnetic suction and spring pivot downward thrust after solenoid is energized, thus control the valve opening[8]. Linear exhaust gas recirculation valve control circuit is shown in Figure 4.

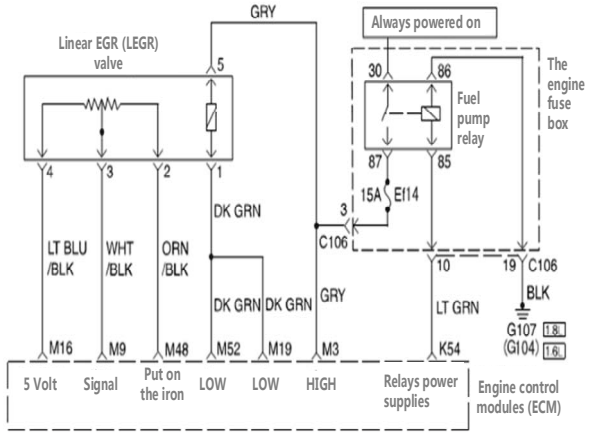

Figure 4 Linear exhaust gas recirculation valve control circuit

As can be seen from the control circuit, linear exhaust gas recirculation valve has five terminals. Engine control modules (ECM) controls the valve opening by controlling the magnitude of the electromagnetic coil current between terminal 1 and 5. Engine control module (ECM) provide 5V operating voltage for the coils between terminal 2 and 4,in the course of work, the engine control module (ECM) controls the valve opening by varying the electromagnetic coil current between terminal 1 and 5 according to the throttle position sensor signal and the intake pressure sensor signal[9]. At the same time, with the varying of electromagnetic coil current between terminals 1 and 5, linear exhaust gas recirculation valve provide a corresponding voltage signal to the engine control module (ECM) through the terminal 3. With this signal, the engine control module (ECM) can monitor the valve opening to see whether it meets the requirement at any time.

Vehicle maintenance and repair personnel can use a fault diagnosis tester to monitor the feedback signal, which is the actual position of the exhaust gas recirculation valve pivot. The actual position of the EGR valve position should always be close to the directive or ideal exhaust gas recirculation valve position[10].

If the exhaust gas recirculation system break down, maintenance personnel can use a fault diagnosis tester(eg TECH2 or GDS) to read the fault codes or other error messages, so that the fault can be ruled out as quickly as possible. The common faults of Exhaust gas recirculation system include:

A. less exhaust gas recirculation flow rate, exhaust gas recirculation is less than 1%. Fault code: P0402;

B. excess exhaust gas recirculation flow rate, the time of exhaust gas recirculation valve position during the start for more than 70% is more than three seconds. Fault code: P0404;

C. the exhaust gas recirculation valve opening error, the difference between current position and the commanded position is more than 15%. Fault code: P0405;

D.the voltage of exhaust gas recirculation valve pivot position is too low, the EGR position signal is less than 2%. Fault code: P0406;

E.the voltage of exhaust gas recirculation valve pivot position is too high, the EGR position signal is greater than 98%. Fault code: P0420.

For each of the above faults, there is corresponding fault diagnostic program in the repair manuals. As long as the maintenance personnel perform the fault diagnostic program strictly and accumulate experience constantly, the failure will be successfully removed. If necessary against the data stream can be assisted troubleshooting Tbable 1 is measured data Shanghai Buick 3.0L engine working.

TABLE 1.MEASURED DATA SHANGHAI BUICK 3.0L ENGINE WORKING.

Measured data Shanghai GM Buick 3.0L under normal operating conditions				
Engine project **L46**	50°C Idle	Normal temperature Idle	Normal temperature 2000r/min	Normal temperature Hard acceleration moment
Engine speed	1140 r/min	720r/min	2000r/min	3605r/min
Setting idle	1087r/min	725r/min	725r/min	725r/min
Start up ECT	6°C	103°C	103°C	103°C
ECT	6°C	103°C	99°C	104°C
Start up IAT	3°C	45°C	40°C	45°C
IAT	3°C	36°C	26°C	30°C
TP Sensor	0.65V	0.63V	0.94V	4.53V
MAP sensor	1.45V	1.56V	1.22V	4.94V
MAP	38Pa	40Pa	33Pa	103Pa

V.SUMMARY

Easy to see, automotive engine exhaust gas recirculation system common fault was able to be diagnosed and removed successfully, thanks to the design features of linear exhaust gas recirculation valve. It is because of the engine control module (ECM) can control the electromagnetic coil current by controlling the linear exhaust gas recirculation valve, and control the valve opening accurately, so that be effective in reducing the emission of nitrogen oxides (NOx). At the same time, due to the linear exhaust gas recirculation valve give feedback signal to the engine control module (ECM) during the work and make the engine control module (ECM) keep knowing the condition of linear exhaust gas recirculation valve at any time, and adjust it to the best condition. Can we find system failure timely, the engine control module (ECM) light fault indicator after three consecutive engine ignition cycles failure. The engine control module (ECM) also records the working condition of diagnosis failure, and saves the information in the freezing fault status and fault recording cache. This creates a favorable condition for maintenance personnel to diagnose and remove fault.

In the study and research as well as maintenance and troubleshooting of vehicle emission control system, we must fully understand the characteristics of engine exhaust gas recirculation system, especially the structural characteristics ,the working principle and control circuit. By measuring the circuit and using fault diagnostic system to detect common faults to improve diagnostic capabilities, and lay a solid foundation for future research in the automotive or maintenance work.

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