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STRUCTURE AND OPERATING PRINCIPLES OF THE FUEL SUPPLY SYSTEM OF INJECTOR ENGINES

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Abstract

History of fuel supply system of injection engines, structure of the fuel supply system of injection engines, division of the fuel supply system of injector engines into main groups, timely maintenance of the engine, multi-point fuel injection system is also installed in Nexia car engines of GM-Uzbekistan joint venture.

Key words

The main elements of the K-Jetronic system, KE-Jetronic system composition, KE-III-Jetronic system, "L-Jetronic" fuel injection system general section, "L-Jetronic" fuel injection system operation, "LH-Jetronic" fuel injection system.

Currently, there are two types of electronic control of fuel transmission used in gasoline engines: electronically controlled carburetor and injection systems. Injection systems are divided into 3 types depending on the place of fuel delivery: central single-point, distributed multi-point and direct combustion chamber injection systems. Due to the complexity of its equipment and the need to use gasoline of very high quality, the level of use of the system of direct injection of fuel into the combustion chamber is not high at the moment. Modern car engines mainly use single-point and distributed multi-point injection systems. In both systems, fuel is injected into the intake tract of the engine cylinders [1].

Electronic control systems of fuel injection work according to the following principle. Since the electric fuel pump maintains a constant pressure of about 0.2...0.3 MP in the fuel distribution pipe, the amount of fuel injected into the cylinders is determined by the time the electromagnetic injector (injector) remains open. The electronic control system controls the opening and closing of the injectors, i.e., the duration of the forced injection pulse into the cylinders, depending on the angle of opening the throttle valve, the frequency of rotation of the crankshaft, the temperature of the coolant and the absolute pressure in the inlet pipe. Information about the amount of fuel to be injected is stored in a non-volatile memory device in the form of a two-digit code. The electronic control unit, based on the information from the sensors, selects the necessary code from the non-volatile memory device and ensures that the corresponding amount of fuel is sprayed around the intake valves of the engine [2].

The fuel injection system was first installed by the Mercedes company in 1949 on the Mercedes S300 car engine. Tests have shown that this system is superior to the carburetor in all key parameters. After that, many well-known companies of the world began to engage in the production and improvement of the fuel injection system and offered their various designs. Among them, the K-Jetronic mechanical continuous spraying system presented by Bosch (Germany) in 1951 was recognized as the most successful in terms of cost and reliability [1-2].

Figure 1. Construction of the K-Jetronic mechanical continuous spraying system provided by Bosch.

The name of the K-Jetronic system is the result of shortening three words. K-is derived from the German word kontiuerlich (continuous), Jet from the English word for stream, and has been adopted as the traditional ending of ronic-modern technical terms.

Later, mechanical continuous spraying systems developed in other countries of the world were included in the "K" group.

According to the Bosch company, from 1951 to 1989, the mechanical fuel injection system was installed in 50 million units in the world. installed on more than 100,000 cars. In the territory of the former Union, including Uzbekistan, cars equipped with a mechanical spraying system are currently being used.

Gasoline engines equipped with a fuel injection system are increasingly used in modern cars [3].

According to the principle of operation, fuel injection systems can be divided into the following 5 main groups: "K", "Mono", "L", "M", "D".

- "K" group includes multi-point, mechanical continuous fuel injection systems (K-Jetronic, KE-Jetronic. These systems were released before 1989);
- "L" group includes multi-point, pulsed fuel injection systems controlled by an electronic block, which are most widely used in modern cars (L- Jetronic, LE- Jetronic, LH-Jetronic, VAZ);
- "Mono" group consists of sprinkler systems controlled by a central (single-point) pulsed electronic unit (Mono-Jetronic, Opel-Multik, G-Motors, VAZ);
- Group "M" is a fuel injection system of group "L" or "M" in the automatic engine control electronic system. In the systems included in this group, the processes of fuel injection and ignition are controlled together. (Motronis, L-Motronis, Mono-Motronis, Fenix, Mikas, VAZ)
- "D" group is a system of direct injection of fuel into the combustion chamber of each cylinder, controlled by the on-board central computer. This is a promising system, and the engines installed in it are very economical [4].

Bosch's K-Jetronic injection system is a mechanical system with continuous fuel injection, which is used in AUDI-80 and -100; BMW-320i and 520i; Installed on Mercedes-Benz-450 and other models. Fuel is delivered under pressure to injectors located in front of the intake valves in the intake manifold. The nozzle opens under the influence of fuel pressure and sprays it continuously. Fuel pressure depends on engine load and cooling system temperature.

One of the main elements of the K-Jetronic system is the regulator distributor. It determines the amount of fuel to be injected based on the amount of air entering the cylinder and the value of the control pressure.

Automatic electronic control of the fuel injection process in car engines was implemented for the first time using the KE-Jetronic system. This system is installed on Audi-80 and 100, Ford Escort, Mercedes-Benz-190 and other cars.

In the KE-Jetronic system, as in the K-Jetronic system, the fuel is injected continuously by means of a closed type hydromechanical injector, and the quality of the fuel-air mixture is controlled electronically. Therefore, the K-Jetronic system, which improved the quality of the fuel-air mixture with an electronic control system, began to be called KE-Jetronic (from the word Ye-electronic) [5].

In order to ensure electronic control of the quality of the fuel-air mixture, four new devices are included in the KE-Jetronic system:

- Electrohydraulic adjuster of control pressure;
- Membrane pressure regulator;
- Air meter equipped with a potentiometer sensor;
- Electronic control unit (EBB).

The control pressure regulator with a bimetallic plate is removed from the KE-Jetronic system, and the meter-distributor has a different structure.

Depending on the type of car engine, the number of input sensors to the electronic control unit can be from 4 to 11. For example, in the KE-III-Jetronic system intended for installation on Audi-80 car engines, there are 10 such sensors: engine temperature sensor, throttle position sensor, altitude sensor, engine load sensor (by the position of the pressure disc), revolutions frequency sensor, calculation head sensor, oxygen concentration sensor (**λ -probe**), automatic transmission connection sensor, salt operation sensor, air conditioner connection sensor.

These sensors, together with the electronic control unit and the regulator-distributor, ensure the necessary mixing of fuel and air in the mechanical fuel injection system.

L-Jetronic fuel injection system. L-Jetronic is an electronically controlled, multi-point, distributed fuel injection system. In this system, all injectors have electromagnetic control [4-5].

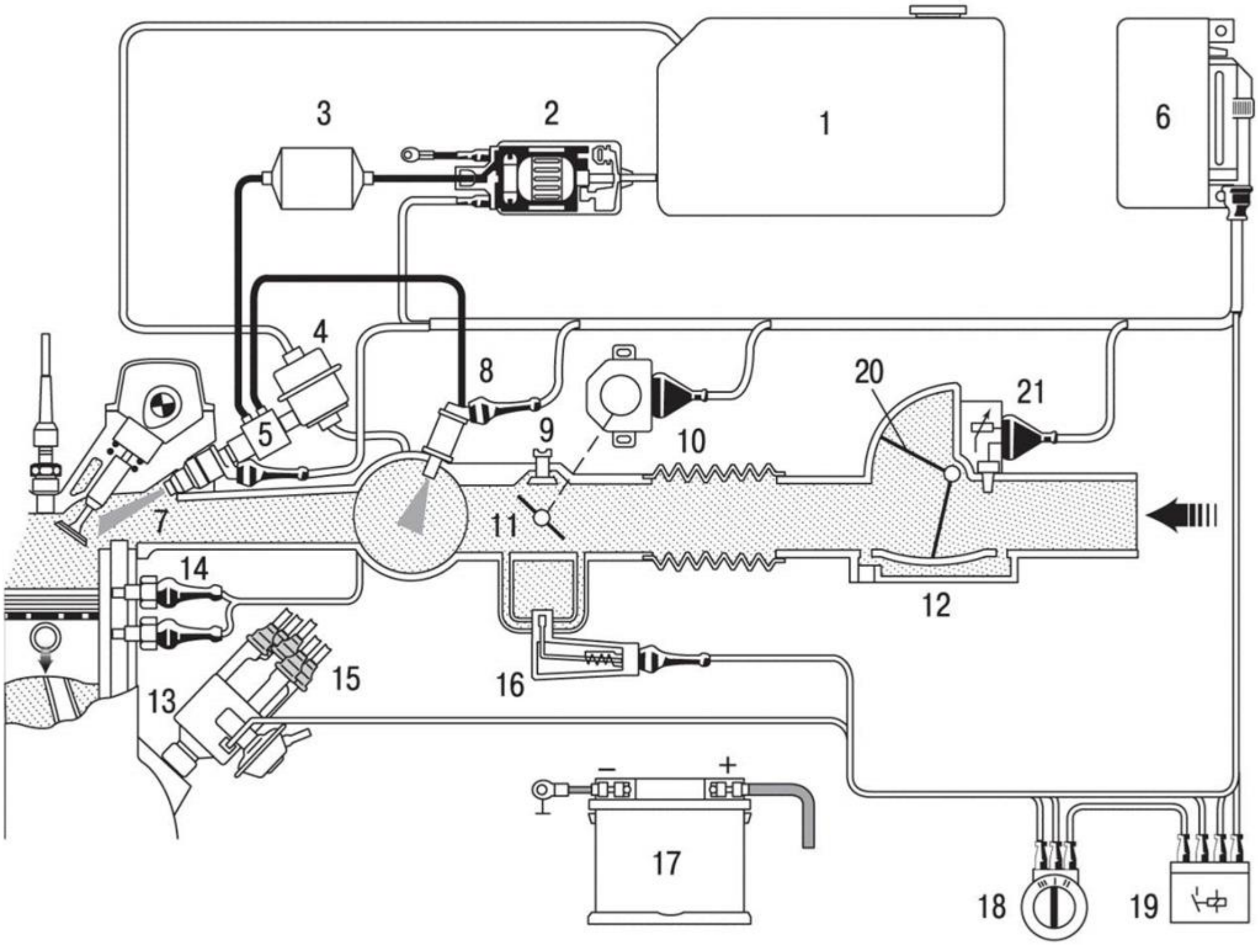

Figure 2. "L-Jetronic" fuel injection system.
1 - fuel tank; 2 - fuel pump; 3 - fuel filter; 4 - fuel distributor; 5 - pressure regulator; 6 - control unit; 7 - injector; 8 - cold start injector; 9 - idle speed adjustment screw; 10 - throttle position potentiometer; 11 - throttle valve; 12 - air flow meter; 13 - temperature sensor; 14 - temperature-time sensor; 15 - ignition distributor; 16 - idle speed regulator; 17 - battery; 18 - ignition switch; 19 – relay

"L-Jetronic" is a highly improved system that significantly increases engine efficiency, reduces toxic substances in exhaust gases and improves overall vehicle dynamics.

The fuel injection system "L-Jetronic" works as follows: the electric gasoline pump-2 takes fuel from the tank-1 (Fig. 3) and transfers it to the distributor pipe-4 with a pressure of 0.25 MPa through the fuel cleaner-3. The distributor pipe is connected with working nozzles - 9 using special hoses. The pressure regulator - 5 placed at the other end of the distributor pipe serves to maintain the fuel pressure in the system at the set value level and return the excess fuel to the tank - 1. In this way, it is ensured that the fuel circulates continuously and that steam plugs do not form in the system [6].

The amount of injected fuel is determined by the electronic control unit - 7 taking into account the volume, pressure and temperature of the air entering the cylinders, as well as the frequency of revolutions of the crankshaft, engine load and the temperature of the coolant.

The volume of air entering the cylinders is the main factor determining the fuel rate. Air volume is determined using a potentiometer air gauge. The incoming air flow turns the measuring block of the air meter to a certain angle, and this turning angle is expressed as an electric voltage by means of a potentiometer. Based on this electrical signal, the electronic control unit determines the amount of fuel corresponding to this operating mode of the engine and sends impulses to the electromagnetic valves of the working injectors that determine the duration of fuel injection. Regardless of the position of the intake valves, in one or two revolutions of the engine crankshaft, the injectors spray the appropriate proportion of fuel into the intake manifold. When the intake valve is closed at the moment of injection, the fuel accumulates in the space in front of the valve and enters the cylinder together with air at the next opening of the valve [1, 6].

The additional air supply valve - 13 is installed in the air duct parallel to the throttle valve, and when starting and warming up a cold engine, it supplies additional air to the engine and allows to increase the frequency of rotation of the crankshaft.

To facilitate the start of a cold engine, the L-Jetronic system, like the injection systems seen above, uses a starting nozzle - 11. The opening duration of the start-up nozzle depends on the temperature of the coolant, which is determined by the thermorelay-14.

A temperature sensor is installed at the inlet of the air meter. In the lower part of the air meter, there is a rotary channel with a quality screw of the fuel mixture - 13.

"LH-Jetronic" fuel injection system. The "LH-Jetronic" system differs from the "L-Jetronic" system mainly in that a different type of air meter is used. The electronic control unit calculates the amount of fuel to be injected depending on the following factors from the sensors installed in the appropriate places of the engine [7]:

- amount of air intake;
- crankshaft rotation frequency and angular position;
- the temperature of the cooling liquid;
- condition of the throttle valve.

Based on the received data, the electronic control unit sends a control pulse that determines the duration of injection and therefore the amount of fuel to all the injectors installed in front of the intake valves.

A thermomagnetometry air meter (Greek, anemos-wind) was used in the "LH-Jetronic" system. The principle of operation of this air meter is based on the correct proportionality of the heat energy required to maintain a constant temperature difference between the heating element placed in the air stream and the air passing around it, to the amount of air passing over the surface of the specified section. A platinum wire with a diameter of 0.07 mm is used as a heating element, which is placed in the middle of a cylindrical air channel. The difference between the temperature of the intake air and the temperature of the platinum wire heated by current is always kept at 150^{o} C. The current through the wire varies from 500 mA to 1500 mA. The amount of current required to flow through the wire to maintain a constant temperature difference between the air and the wire is a measure of the mass of air entering the engine. The amount of current required to flow through the wire to maintain a constant temperature difference between the air and the wire is a measure of the mass of air entering the engine. Air measurement range is 9...360 kg/h. During operation, the platinum wire is covered with organic matter and becomes contaminated. In order to clean it, every time the engine stops, the wire is automatically heated to $1000...1100^{o}$ C and the substances stuck to it are burned [8-9].

Thermomagnetometry air meters provide an opportunity to make a connection between the air and fuel masses entering the engine with great accuracy. But the high price of this type of air meter limits their wide use.

Fuel is supplied to the engine through injectors placed in the intake manifold of each cylinder. An oxygen concentration sensor is also used as the main sensor for this system. Based on the signal from the oxygen sensor installed in the exhaust manifold, the electronic control unit adjusts the composition of the fuel-air mixture delivered to the engine, that is, it brings it closer to the stoichiometric ratio [11-12].

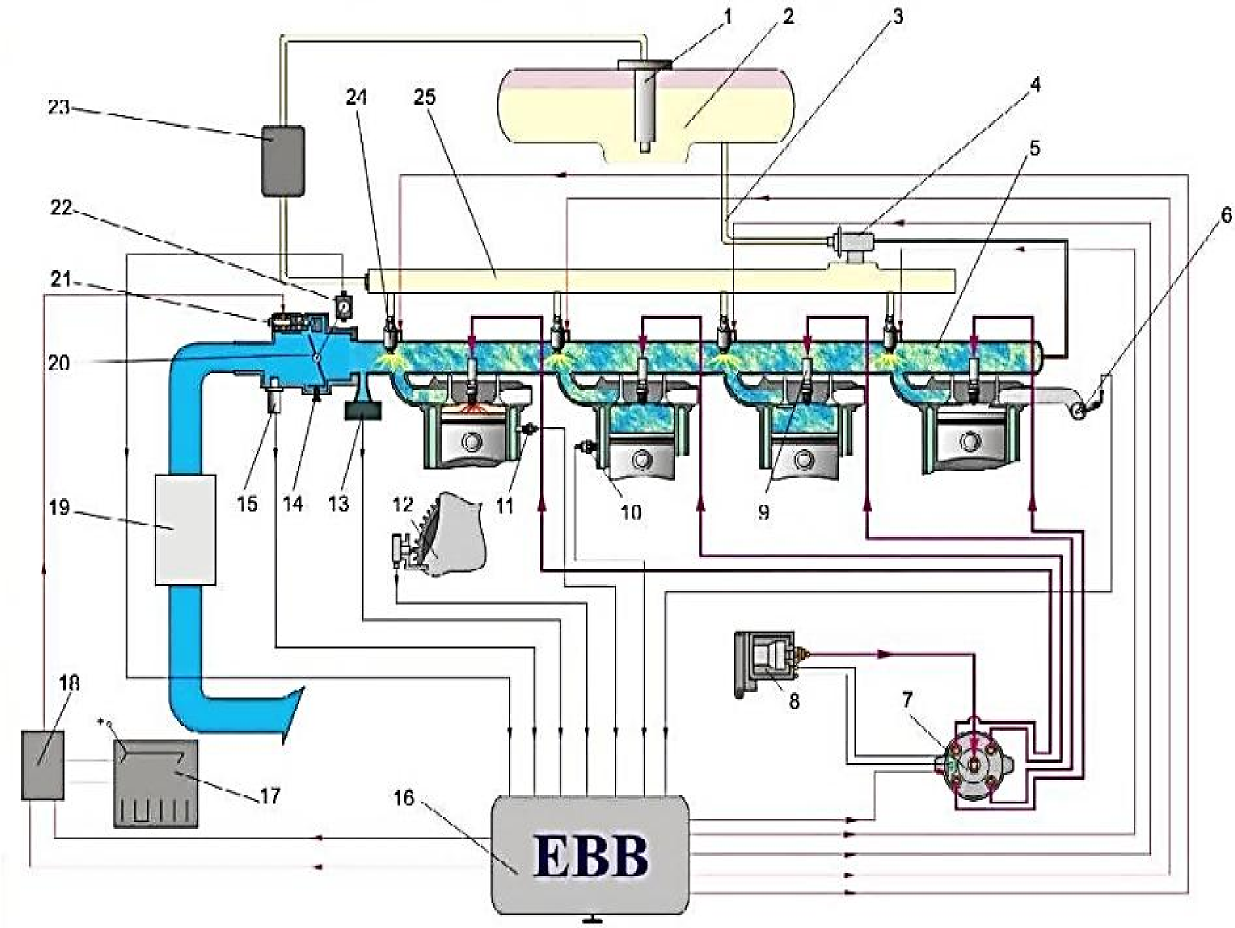

Figure 3. Fuel injection system in Nexia car engine:
1- electric gasoline pump; 2- fuel tank; 3- fuel return pipe to the tank; 4- pressure regulator; 5-inlet pipe; 6-oxygen sensor;7-sensor-distributor;8-ignition coil;9-lighting candles; 10-oil pressure sensor; 11-coolant temperature sensor; 12-crankshaft rotation frequency and position sensor; 13-absolute pressure sensor; 14-travel adjustment screw; 15-air temperature sensor; 16-electronic control unit; 17-ignition key; 18-relay block; 19-air cleaner; 20-throttle barrier; 21-additional air transfer valve; 22-throttle barrier position sensor; 23-fuel cleaner; 24-injector; 25-fuel distribution pipe.

A multi-point fuel injection system is also installed in the Nexia car engines of the GM-Uzbekistan joint venture. An absolute pressure sensor with a piezometer was used to measure the amount of air entering.

Timely maintenance of the engine. Maintenance of the fuel supply system is not a difficult task. The most important thing is to follow the manufacturer's recommendations for regular maintenance:

- Change the air filter in time;
- Do not forget to replace the fuel filter;
- Periodically check the contacts of the system sensor for oil or dust contamination;
- Do not drive with an almost empty tank (this often causes the fuel pump to fail);
- Fill the tank with the correct fuel.

These simple rules prevent unnecessary waste when repairing failed elements. As for setting the engine operating mode, this function is performed by the electronic control unit. Only when there is no signal from one of the sensors on the instrument panel, the Check Engine light comes on. Even with proper maintenance, it is sometimes necessary to clean fuel injectors [13].

The following factors may indicate the need for such a procedure:

- The engine is not working well;
- Floating idle speed;
- Decreased dynamics during overclocking;
- The car became more "saturated".

Basically, because of the impurities in the fuel, the injectors get clogged. They are so small that they pass through the filter elements of the filter.

The injector can be washed in two ways: take the car to a service station and perform the procedure at the stand, or do it yourself using special chemicals. The second procedure is carried out in the following sequence [14]:

- First, you will need to create an alternative fuel system - a small tank into which fuel is poured, a cleaner is added to it (the concentration of the substance is indicated on its tank, but often one liter of liquid will re-fill 2.5 liters of engine volume designed to work). Another fuel pump is installed here;
- The engine is warmed up to operating temperature;
- After that, you need to de-energize the main fuel pump. To do this, just remove its fuse;
- Several attempts to start the engine without the pump. This is necessary to reduce the pressure in the line;
- Fuel supply hose is disconnected;
- The return hose must be connected. To do this, it is removed from the fitting and a thick bolt is screwed into it;
- A new fuel system was connected;
- The engine starts. It should work for 5 minutes, after which it freezes;
- In order for the agent to corrode deposits in the nozzles, you need to wait a few minutes and restart the internal combustion engine;
- Allow the engine to run for approximately 2,500 minutes, occasionally increasing the speed to 30 rpm;
- The alternative fuel system is disconnected and the standard one is connected;
- The engine is run for 10 minutes to remove the residue cleaner;

After completing the procedure, the candles are replaced with new ones

Figure 4. The condition of the injector hole.

It should be noted that this cleaning does not remove impurities from the fuel tank. This means that if the cause of the blockage is low-quality fuel, then it should be completely removed from the tank and filled with clean fuel [15].

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