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БЕЗКОНТАКТНО ЗАХРАНВАНЕ И КОМУНИКАЦИЯ НА УСТРОЙСТВО ЗА ИЗМЕРВАНЕ НА ИЗЛИШНАТА НАФТА ПРИ СЪВРЕМЕННИТЕ ДИЗЕЛОВИ ДВИГАТЕЛИ

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CONTACTLESS POWER SUPPLY AND COMMUNICATION OF THE DEVICE FOR MEASURING EXCESS FUEL IN MODERN DIESEL ENGINES

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Abstract

Common Rail systems have the main application in modern cars. The condition of the fuel injectors is of particular importance for monitoring the correct operation of the engine. The main standard for their proper operation is the amount of excess fuel. It was decided to develop a device for monitoring the operation of the nozzles in real time because of the lack of a such.

A device has been created, which consists of a transmitting and receiving module, which work with autonomous power supply with Li-Yon rechargeable batteries, which are charged contactless. The measured amount of excess fuel in real time in all modes of engine operation and the communication between the modules is non-contact.

There was a slight deviation of the results in the practical experiments, because of the difference in the temperature of the fuel measured by the device, which does not significantly affect the final result.

The realized device for measuring the excess fuel fully satisfies the set requirements and can be used in all modern diesel engines. Due to their small size, lack of power cables and communication cables between the two modules, proper nozzle diagnostics and engine operation are observed.

Keywords: Common Rail, Contactless Power Transmission (WPT), Sensor, Bluetooth.

INTRODUCTION

Different types of methods are used to diagnose the correct operation of the nozzles in Common Rail systems. Specialists in this field mainly use the indications from the sensors to draw the appropriate conclusions and on their basis to decide on the repair or replacement of a nozzle. The amount of excess fuel is one of the main indicators of its proper operation. With a larger amount of excess fuel, the mechanical wear is more. The existing way of measuring the excess fuel in practice is reduced to a purely mechanical method - measuring with the help of measuring flasks the fuel separated from each nozzle in cubic centimeters per unit time.

In this regard, it was decided to develop a device with an electronic flow sensor to read the amount of excess fuel and visualize the results in real time using a contactless method for loading and transmitting the received information.

The developed device shows slight deviations depending on the temperature of the excess fuel, but they do not significantly affect the readings.

The development aims to quickly and adequately diagnose the condition of the nozzles in Common Rail systems.

EXPOSITION

1. DEVICES AND METHODS

Wireless remote data transmission systems have evolved and become very common. The information that can be transmitted with them has increased many times and energy consumption has decreased significantly. This helped with a single charge of the batteries they last a long time in active mode of transmission and eavesdropping. Their main advantage is the lack of power cables.

Through the sensors in Common Rail systems, the electronic engine control unit (ECU) collects information about the individual operating parameters of the engine and prepares control signals for the individual actuators involved directly in its operation. Information is obtained about the current state of the engine, the state of the environment, which also affects the operation of the engine, the quality of the exhaust gases of the engine and ets. [1], [2].

Wireless remote data transmission systems have evolved and become very common. The information that can be transmitted with them per unit time has increased many times over. The power consumption of these devices is also significantly reduced, which helped with a single charge of their batteries (if used) to endure several days, even weeks when used continuously in active transmission mode or in eavesdropping mode.

Last but not least, the advantage of these systems is the lack of wires between the individual devices, which facilitates their use.

According to the frequency range of electromagnetic radiation, the methods of energy transmission can be divided into five main groups: inductive, inductive-resonant, capacitive, microwave and laser.

Wireless data devices are those using Wi-Fi technology, ZigBee technology, Nano NET technology, Z-Wave and Bluetooth technology.

Contactless power transmission systems (WPT) have also undergone great development - in particular contactless charging systems for small mobile devices operating at low voltages (up to 12V) and using nickel-metal hydride, nickel-cadmium, lithium-ion, lithium-polymer or nickel-iron rechargeable batteries. The last three of the listed batteries have very good indicators in terms of mass capacity and low tendency to self-discharge.

Different methods are used in the diagnosis of nozzles to judge their condition. Specialists in this field mainly use the readings from the sensors of the Common Rail system to draw the appropriate conclusions and on their basis decide whether to repair or replace a nozzle. One of the main criteria for whether a nozzle is working properly is the amount of excess fuel that comes out of it. The greater the amount of excess fuel, the greater the mechanical wear of the nozzle.

The existing way of measuring the excess fuel in practice is reduced to a purely mechanical method - measuring with the help of measuring flasks the fuel separated from each nozzle per unit time.

Therefore, it was decided to develop a device with an electronic flow sensor to read the amount of excess fuel and to visualize the results in real time.

2. LABORATORY MODEL

The created device for measuring excess fuel is divided into two separate modules. The first module combines the housing of the sensor element and the body. The body also has an analog circuit for signal processing from the sensor element assembled in a plastic box in a common structural unit. It is responsible for processing data from the four flow sensors simultaneously. The device performs subsequent digital processing of their signals by calculating the instantaneous value of the amount of excess fuel from each sensor, the total amount of fuel from each sensor from the beginning of the measurement and transmits the results obtained from the sensors via Bluetooth to the second module.

The second module combines in one common structural unit the scheme for processing the data from the sensor with a single-chip microcontroller and their visualization on an LCD display in digital form and the scheme for real-time data visualization. It receives the information from the first module using a Bluetooth device and visualizes the measurement data on a display for the four sensors simultaneously. A touchscreen device built into the display can be used to control and display, at the operator's request, the current or average value of the amount of excess oil on the display.

The Bluetooth device can be programmed and operated in two modes - as a master and slave device. This allows the same type of Bluetooth device to realize the transmitting and receiving part of the model. Its operating voltage is from 3.3V to 6V, which allows it to be powered either by the battery of the model or by the stabilized voltage of the Arduino module (which is 3.3V). The data transmission speed can be varied and matched to the baud rate of the Arduino module used to implement the layout.

The power supply of the two modules - receiving and transmitting module is done with a lithium-ion rechargeable battery with a capacity of 2200 mAh. Measurement of the current consumed by the modules was made after creating working prototypes of the two modules. It is at a maximum consumption of 40 A-3 for the transmitting module and 80 A-3 for the receiving module, respectively.

The device can work for 8 hours at maximum load in one working day. In this case the current consumed by the battery (3.1) is:

$$I_{8h}=I_{med} \,.\, h \,, \qquad (3.1)$$

where: I_{8h} - current consumed by the module for eight hours of working day (maximum load of the device), I_{med} - average consumption of the receiving module for one hour, h - number of working hours.

The higher current consumption is from the receiving module. It determines the duration of operation of the entire device:

I_{8h} =80.8

$$I_{8h} = 640 \text{ A}^{-3} \text{ (640 mA)}$$

This allows a lithium-ion battery with a capacity of 2200 mAh to be sufficient to ensure trouble-free operation of the device for three working days.

Standard 1, adopted in 2009, is used for the transmission of small powers up to 5 W, at a distance of up to 4 cm (1.6 inches), and energy transfer up to 5 mm can be easily performed. In this standard, the charging station is divided into two parts (Fig. 1).

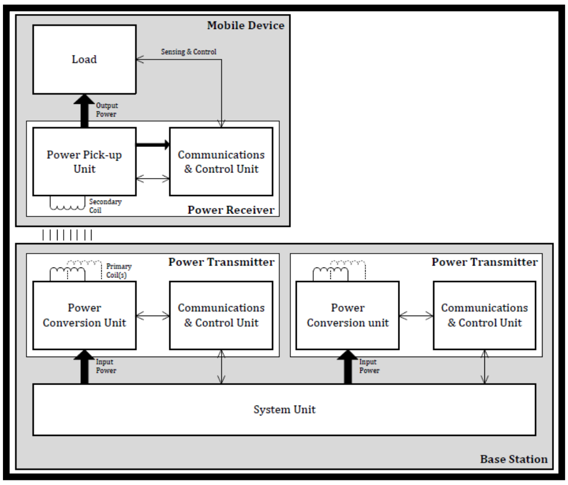

Fig. 1. Schematic diagram of a station for charging small portable devices.

The first part consists of a separate module (Base Station) which combines a system for monitoring the parameters of the charging station (System Unit). From there passes the entire flow of electricity for the mobile device, which is charged as well as a system for transferring energy between the base station and the mobile device.

In this way, a single base station ensures the charging of many different devices, both sequentially during and simultaneously (Fig. 1). It has two separate power transfer systems and allows simultaneous charging of two devices. The number of charged devices can be increased by adding more power transfer systems.

The second part (Power Receiver) is usually integrated into the device that is currently charging or operating and serves to receive the electromagnetic energy emitted by the base station. The basic principle of operation consists in the transfer of electromagnetic energy between the base station and the receiving device by means of planar windings (Fig. 2). Then the same energy is converted into electricity.

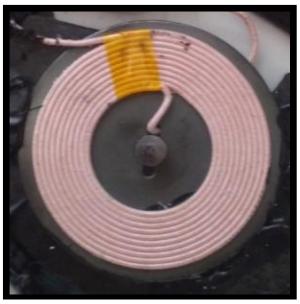

Fig. 2. Planar winding of the base station of the designed device.

The energy transfer system by means of the transfer winding of (Fig. 2) generates an alternating electromagnetic field. The mobile device in which the energy receiver is located contains a receiving coil (Fig. 3). The closer the two windings are to each other, the more efficient the energy transfer.

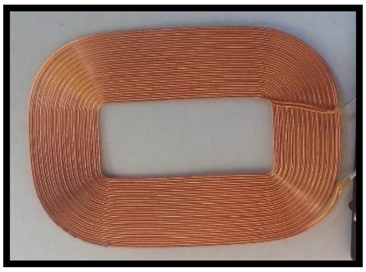

Fig. 3. Power receiving coil.

Depending on the distance between the transmitting and receiving windings, as well as depending on their axial location, the frequency at which the transmitting winding is transmitted can be changed with the help of electronics. This achieves a resonance between the two windings within certain distances and a mismatch between them. This is done by changing the voltage that is fed through the bridge circuit to an oscillating circuit between the transmitting winding and a capacitor connected in series with it. Thus a resonance of about 140 kHz is achieved. Another method for achieving resonance between the transmitting and receiving coils is by changing the value of the capacitors that are connected in series to the transmitting coil. In this way, resonance can be achieved in a relatively wide range of emission frequencies - from 105 kHz to 205 kHz. For this purpose, electronics are built into the base station and the mobile device to monitor the individual indicators and to regulate the parameters to achieve the optimal resonant frequency.

The device for contactless charging of the modules is made on the basis of a basic device and a receiver according to Standard 1, as the transmitted power of 5W (2.1) is sufficient to charge the battery of each of the modules for an acceptable period of time - approximately 2 hours (2.2).

$$P_{nom} = U_{nom} \,.\, I_{zar} \qquad (2.1)$$

where: W_{nom} - power of the transferred energy according to Standard 1 in W, U_{nom} - voltage of the charged battery in V, I_{zar} - charge current in A.

$$I_{zar} = P_{nom} \;/\; U_{nom}$$
$$I_{zar} = 5 / 4.2$$
$$I_{zar} = 1{,}19 \text{ A}$$

The capacity of the selected battery is 2200 mAh which is 2.2 Ah, and the device according to Standard 1 provides 1.19 A current, which is 1.19 Ah.

$$Ah_{bat} = I_{zar} \,.\, t \qquad (2.2)$$

where: Ah_{bat} - battery capacity in Ah, I_{zar} - device charging current according to Standard 1, t - battery charging time in h.

$$t = Ah_{bat} / I_{zar}$$
$$t = 2{,}2 / 1{,}19$$
$$t = 1{,}848 \text{ h} = 1\text{h} , 51 \text{ min}$$

The laboratory model (Fig. 4) is a working device that can be used directly to measure the amount of excess fuel on a four-cylinder diesel engine. The model is divided into three separate modules - charging station, transmitter module and receiver module.

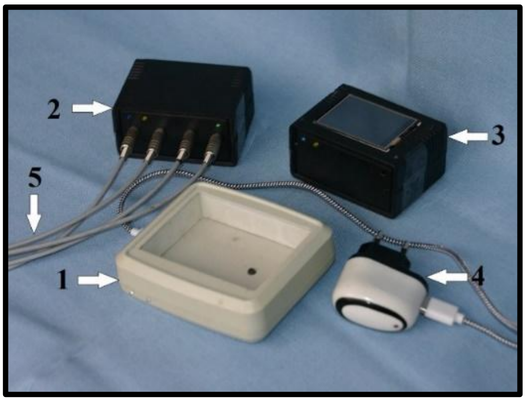

Fig. 4. Laboratory model of the device. 1 - charging station, 2 - first (transmitting) module; 3 - second (receiving) module; 4 - transformer 220V / 5V; 5 - three-core conductors.

The block diagram of the developed laboratory model is presented on (Fig. 5).
It contains a measuring part consisting of the "5V power supply", "primary converter" and "primary signal processing" units, a real-time signal processing part consisting of the "8V power supply" units, a " real-time signal processing circuit" and "LED indication", a part for digital signal processing, consisting of blocks "digital signal processing scheme" and

"LCD display".

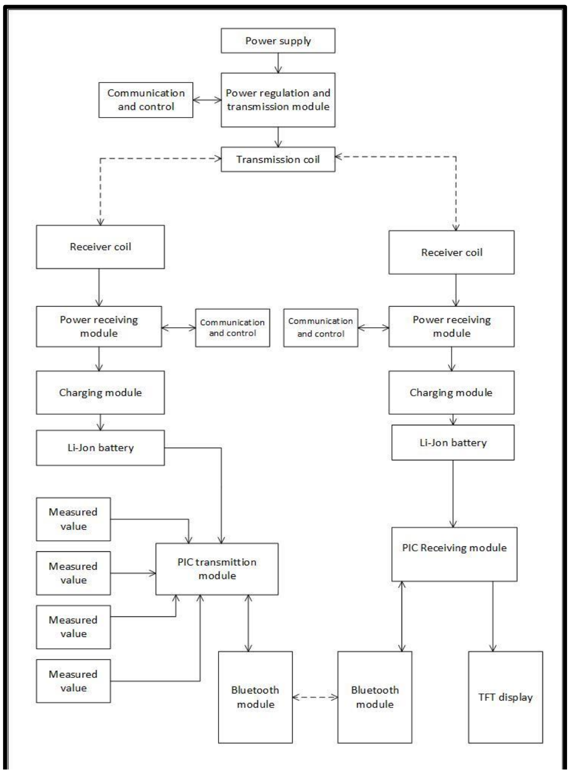

Fig. 5. Block diagram layout

3. EXPERIMENTAL RESEARCH

The most important feature of the laboratory model is the values calculated by the transmitter module based on the analog signals from the four sensors and the built-in schemes for initial signal processing, and their subsequent sending via the communication channel to the Bluetooth module (Fig. 6.).

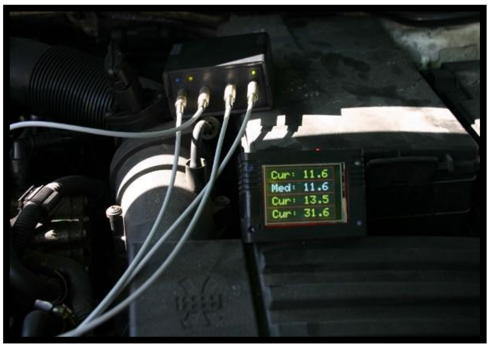

Fig. 6. Model in real working conditions

It clearly shows the current and average values of the calculated amount of excess fuel from the four cylinders of the car. The second row shows the average value for the second cylinder.

CONCLUSION

The implemented flow sensor fully met the requirements. Can be used on all types of Common Rail systems. Its compact size, low dependence of its readings on the temperature of excess fuel and its autonomous operation, give great freedom in performing the procedure for diagnosing diesel nozzles. The great freedom in performing the diagnostic procedure of the diesel nozzles is given by its compact size, the low dependence of its readings on the temperature of the excess fuel and its autonomous operation. The model realized in this way enables independently perform the entire of the whole procedure for testing the nozzles. The division of the device into two separate modules, the wireless communication and the autonomous power supply without connecting wires determines the fast and correct testing of the operation of the nozzles even during road tests. In the future, the stand for measuring excess fuel can be further developed and based on it to create a device for measuring six or eight diesel nozzles at the same time, as well as to introduce a temperature adjustment of the measured fuel for even greater accuracy.

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