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Improving The Adaptability Of Vehicles To Low-Temperature Operating Conditions.

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ABSTRACT

The article considers the features of the operation of vehicles in low temperature conditions. Low temperature, which is the main indicator of the climatic conditions in the Russian Federation, affects the temperature regime of the units and assemblies of vehicles. In this case, the greatest difficulty in operating vehicles in low-temperature conditions is associated with starting the engine. At present, there are various methods to facilitate engine startup; in particular, these are various heaters or devices that retain heat after the engine has been running for a long period. However, these systems have high inertia, manufacturing complexity and lack of the ability to maintain the working temperature of the process fluid for a long period of time. Therefore, at present, a modern method of heating process fluids of vehicles associated with the use of ultra-high frequency radiation is actively developing. This method allows not only to preheat the process liquid instantly, but also to maintain their operating temperature by turning the magnetron on and off with a command from the thermal sensor. As a result, the use of this system will lead to a reduction in the start-up time of the internal combustion engine at any time.

Keywords: vehicles, microwave radiation, adaptability, low temperature conditions, process fluids

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INTRODUCTION

Automobile transport is one of the main sources of pollution in large cities, especially located in low-temperature natural and climatic conditions [1,2]. This is due to the increase in the duration of the heating of components and assemblies of vehicles, increased fuel consumption, and consequently, an increase in emissions of harmful substances with exhaust gases into the atmosphere [3,4,5]. At the same time, an unfavorable ecological situation leads to an increase in the number of congenital and acquired chronic diseases, such as asthma, allergies and so on. Features of the Russian Federation territory location determine the operation of a large part of the vehicle fleet in low temperature conditions. Low-temperature conditions are in operating conditions in which the ambient air temperature is below the standard value (+25°C) [6,7,8, 9,10]. The adaptability of vehicles, which is understood to be their ability to maintain the values of performance properties at a nominal level when the operating conditions deviate from the standard, is significantly different. Negative temperatures have a significant impact on the temperature regime of vehicle units.

When any equipment, in particular vehicles, operates, the launch of the power unit, warming up of the main units, units and systems up to the operating temperature is necessary. At present, the launch of power units is fraught with difficulties in low temperature conditions. The main components, assemblies and systems are heated to operating temperature mainly due to heat transfer from the walls of the combustion chamber to the cooling fluid, friction, namely gearing gears and piston rings of cylinders in gears, throttling flowing in shock absorbers and hydraulic cylinders. This process is lengthy and leads to significant wear of all contacting elements, and, therefore, causes a decrease in their service life and reliability. These processes occur until the operating temperature of the process fluids. Process fluids are fluids used in assemblies, assemblies and systems during the operation of vehicles and technological machines, namely engine, transmission, hydraulic oils, coolants, fuels, brake fluids used in brake systems, clutch systems, power steering and others. The temperature of process fluids is not always constant, may vary and is not always optimal. For example, the coolant temperature rises in the forced mode, and during long periods of inactivity it decreases.

Particular attention is paid to the start-up of vehicle engines in harsh conditions, that is, at low temperatures. These conditions affect the quality of atomization of fuel injectors, which makes it difficult to start a diesel engine. This is due to an increase in the viscosity of diesel fuel and an increase in its surface tension forces, a decrease in the frequency of rotation of the camshaft of the high-pressure fuel pump and the speed of the plungers of the injection sections, which leads to a decrease in the pressure of the fuel injected into the nozzle and a corresponding decrease in the lift of the nozzle needle. As a result, a smaller gap between the saddle and the locking part of the needle of the dispenser is formed, the resistance of the injection increases, which reduces the flow rate of fuel from the dispenser. At the same time, at the end of the cycle, a reduction in the quality of atomization of fuel in combination with a decrease in air temperature increases the period of delay in auto-ignition of the fuel, making it difficult to start the engine. Sometimes a combination of these factors does not provide for the self-ignition of diesel fuel, and starting the diesel engine becomes impossible. Practice shows that, according to the conditions of auto-ignition and fuel procuring, reliable start-up of a diesel engine can be carried out at an ambient air temperature not lower than -15°C. Lower air temperatures necessitate the use of tools to facilitate the start-up of diesel engines.

METHODOLOGY

The following methods are available to facilitate engine starting in low ambient temperatures:

- it is the use of low viscosity engine oils. The disadvantage of this method is that almost all oils freeze at temperatures below -35°C;
- it is warming up the engine using hot water poured into the cooling system. The disadvantage of this method is its long duration (up to 5 minutes) and the need for a source of hot water;
- it is the heating of the oil in the crankcase of the engine with the help of heaters of various types The disadvantages of this method are the long duration of heating and the availability of additional power sources and special equipment;

- it is an engine start towing. The disadvantages of this method are large shock loads on the undercarriage, transmission and engine, which can lead to breakdowns, as well as a significant heating time;
- it is the use of means of facilitating engine start-up at low temperatures.

Means that facilitate the start-up of a diesel engine in low-temperature conditions reduce the moments of resistance to rotation of the crankshaft, improve the conditions of formation and ignition of the air-fuel mixture, affecting the individual systems of the engine, the temperature state of its parts and operating materials. The effectiveness of various methods and devices to facilitate starting depends on the type of engine, its design features and operating conditions.

Maintaining the temperature of process liquids at an optimal level is necessary for the efficient operation of the equipment. The optimum temperature of process liquids provides the least wear of components and assemblies, reduces fuel consumption, reduces emissions of harmful substances with exhaust gases. The optimum temperature of the oil used in the engine and gearbox allows you to improve the lubrication process of moving parts by improving the penetrating power of the oil into the gap between the contacting surfaces. Optimum temperature of hydraulic oil reduces the risk of failure of high-pressure units due to optimal oil viscosity. The optimum coolant temperature of the internal combustion engine provides the best conditions for the mixture formation and combustion of the fuel in the engine cylinders, improving the process of mixing the fuel with air. The optimal fuel temperature improves the process of mixing, increases the temperature of the cycle and, as a consequence, the complete combustion of fuel, reduces fuel consumption and emissions of harmful substances at idle.

At present, used heaters have a general principle of operation, which consists in heating process fluids due to heat transfer from the heated body (electric heater, exhaust gas heat exchanger, coolant heat exchanger). These principles have a large inertia and do not allow to maintain a given temperature of the process fluid. Devices that provide this method have a high metal consumption, are not reliable in operation, and require additional costs for ensuring their operability.

At the present time, the most promising method is to heat and maintain the optimum temperature of process fluids in an electromagnetic field with ultra-high frequency (UHF) radiation. In this case, the energy of the electromagnetic field of the microwave is converted into thermal energy within the entire volume of the process fluid (dielectric) [11,12,13,14,15]. Under the influence of the electromagnetic field of the microwave, molecule dielectric is polarized and it performs mechanical vibrations, the energy of which is converted into heat due to intermolecular friction, and the dielectric is heated. Maintaining the temperature of the process fluid (dielectric) occurs due to short-term switching on and off of the source of microwave radiation. Heating is carried out in the electromagnetic field of the microwave in the technologically necessary frequency range, based on the volume of the process fluid, its physicochemical properties, initial and final heating temperatures and other factors.

The positive results of the experiment with diesel fuel, obtained by Smolin A. with a device power up to 1.5 kW and a heating time of 60 s at a fuel temperature below -20 ° C, are presented in Figure 1.

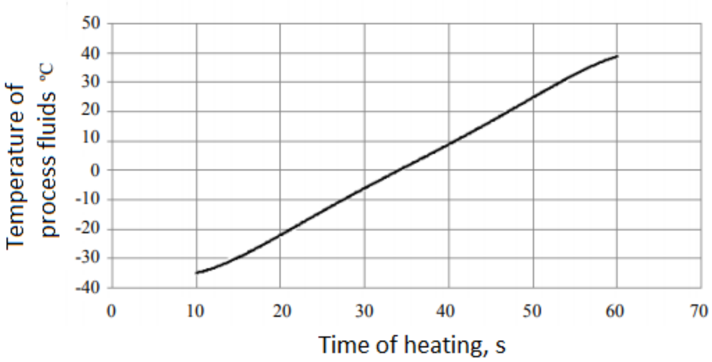

Figure 1. The dependence of fuel temperature on the time of microwave heating at a power of 1.5 kW.

The most significant influence on the optimization of the average diameter of the droplets of fuel and the uniformity of atomization of the fuel have the power of the microwave device and the heating time. When the initial temperature of the fuel decreases, which depends on the ambient air temperature, the average diameter of the fuel droplets decreases during 20-30 seconds of heating with microwave power up to 500W. This is due to the fact that in the initial period of heating, when the fuel remains cold, convective heat exchange in the heating chamber of the fuel is practically absent. In the research of Smolin A., the possibility of using microwave energy in vehicles to facilitate the start of diesel engines is justified in low temperatures (from -35°C to -50°C).

Using microwave heating, when the oscillation frequency and parameters of the chamber where the conversion of microwave energy into heat occurs, is rationally selected, heat can be generated uniformly throughout the body. The efficiency of converting the energy of an electric field into heat increases in direct proportion to the frequency of oscillations and the square of the electric field intensity. At the same time, the simplicity of supplying microwave energy to practically any part of the heated body is noted. Therefore, the goal is to develop a system for heating and maintaining the optimum temperature of process fluids in a vehicle using currents of extremely high frequency.

RESULTS AND DISCUSSION

The authors of the article propose a method of ensuring the optimum temperature of the process fluid in vehicles and technological machines using microwave heating. The method consists in heating the process fluid by applying microwave heating, and maintaining its optimum temperature by fixing it with a thermal sensor and switching the microwave oscillator on and off by the control unit. Diagram of the device is shown in Figure 2.

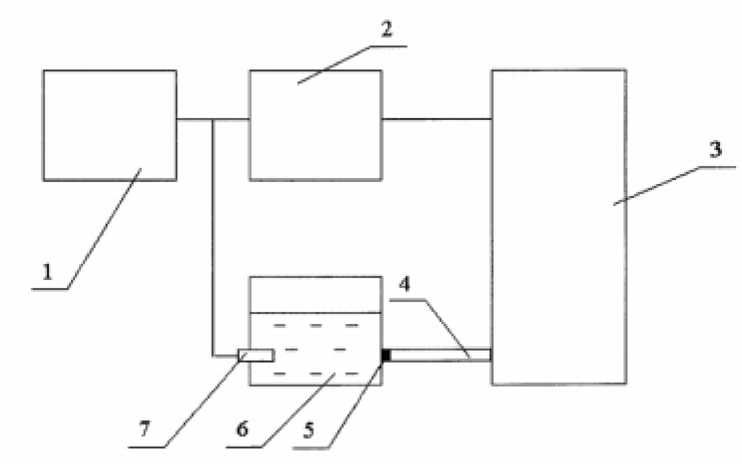

Figure 2. Diagram of the device operation principle for heating and maintaining the optimum temperature of process fluids in vehicles

The device for heating and maintaining the optimum temperature of process liquids in vehicles and technical machines contains a power source 1. The power source is connected to the control unit 2 via a transmission line. The control unit 2 is connected to the generator of microwave oscillations 3 also through the transmission line. The microwave oscillation generator 3 is connected to the compartment 6 containing the process fluid using a waveguide 4 with an emitter 5. In the compartment 6 with the process liquid, a thermal sensor 7, transmitting information about its temperature to the control unit 2 through the transmission line, is installed.

The operation of the device is as follows. The control unit 2, connected to the transmission line with the power source 1, receives a signal about the temperature of the process fluid, located in the compartment 6, from the temperature sensor 7. If the temperature of the process fluid is below its optimal value, then the control unit 2 turns on the microwave oscillator 3 through the transmission line. Next, the electromagnetic field of ultra-high frequency is transmitted from the generator of microwave oscillations through the waveguide 4 with the emitter 5 into the compartment with the process fluid 6. In the compartment 6, the process fluid is heated by converting the energy of the electromagnetic field of the microwave to thermal energy within its entire volume (dielectric). Under the influence of the electromagnetic field of the microwave molecule dielectric is polarized, and it perform mechanical vibrations, the energy of which is converted into heat due to intermolecular friction, and the dielectric is heated. When the process fluid reaches the set optimal temperature in compartment 6, the thermal sensor 7 sends a signal to the control unit 2, which turns off the microwave oscillator 3. When the temperature of the process fluid is below the optimal value in compartment 6, the device is switched on again.

The sequence of operation of the device is as follows. If the temperature of the process fluid is below the optimal value to maintain the effective operation of a particular unit, assembly, vehicle system, the device for heating and maintaining the optimum temperature of the process fluid in the vehicles is turned on. The process fluid is heated to the optimum temperature, after which the device shuts off. If the temperature of the process fluid is above the optimal value, the device does not turn on. When the temperature of the process fluid drops below the optimal value, the device turns on.

The authors of the article also consider the implementation of the method and device for a specific example, which is presented in Figure 3.

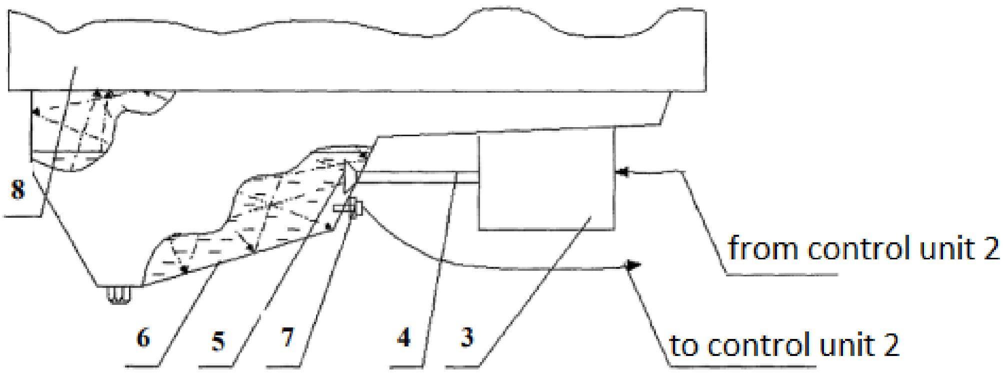

Figure 3. An example of a device for heating and maintaining the optimum temperature of process fluids in vehicles

In a vehicle with an internal combustion engine, the proposed device contains a power source 1, which is not shown in Figure 3. The power source is connected to the control unit 2 via a transmission line. The location of the control unit does not matter and does not affect the desired technical result. In this case, the control unit 2 is connected to a generator of microwave oscillations 3 installed on the sump of the internal combustion engine. The location of the generator of microwave oscillations does not matter and does not affect the desired technical result. Waveguide 4 (with emitter 5) is inserted through the technological hole with one end into the inside of the crankcase 6 containing engine oil. In the sump 6, the temperature sensor 7, which transmits information about the oil temperature to the control unit 2, is installed through the process opening. The crankcase is attached to the engine block 8.

The proposed method is as follows. The control unit 2, connected via a transmission line to the power source 1, receives a signal from the temperature sensor 7 about the temperature of the engine oil in the sump 6. If the temperature of the engine oil is below the optimal value (plus 80° C) (for different internal combustion engines, the optimum temperature of the engine oil may be different), then the control unit 2 switches on the microwave oscillation generator 3 through the transmission line. The electromagnetic field of ultra-high frequency (frequency of about 3.2 GHz) is transmitted from the generator of microwave oscillations through waveguide 4 with emitter 5 to the compartment with process fluid 6. In the oil sump with engine oil 6, the engine oil is heated by converting the energy of the electromagnetic field of the microwave into thermal energy within the entire volume of the process fluid (dielectric). When in the sump 6, the temperature of the engine oil reaches a predetermined value (plus 80 ° C), the thermal sensor 7 sends a signal to the control unit

2, which turns off the microwave oscillation generator 3. When in the sump 6, the temperature of the engine oil is below the optimum value (plus 80 ° C), the device is put back into operation.

The power source is a rechargeable battery, a generator, an electrical network, or other device that produces an electric current. The control unit may be a microprocessor, relay, other device that allows you to close or open the electrical network. The control unit may have a control lamp (lamp) to inform about the operation of the microwave heating device and maintain the optimum temperature of the process fluid. The control unit can operate in automatic mode and have a remote control. The microwave oscillation generator is a magnetron, amplitron, transient multiresonator klystron, or other device that creates an electromagnetic field of ultra-high frequency.

The use of additional microwave heating of process fluids will reduce the time to start up the power unit, warm the main components, units and systems, as well as ensure the maintenance of their optimum temperature.

CONCLUSION

Improving the adaptability of vehicles to low-temperature operating conditions can reduce fuel consumption and, consequently, emissions of harmful substances. This causes a decrease in the negative impact on human health.

The authors of the article proposed a modern method and device for heating process fluids in nodes and assemblies of vehicles, which contributes to reducing the start-up time of engines, and therefore the adaptability of vehicles to low-temperature operating conditions. In the course of experimental studies, the authors of the article developed the principle of operation of the device, which consists in heating process fluids in an electromagnetic field. In the course of experimental studies, the authors of the article developed the principle of operation of the device, which consists in heating process fluids in an electromagnetic field. At the same time, when the initial temperature of the fuel is low and the heating is carried out for 20-30 s at low microwave power to 500W, the diameter of the fuel droplets decreases slightly, but it is heated.

Therefore, the use of additional microwave heating of process fluids will reduce the time to start up the power unit, warm the main components, units and systems, as well as ensure the maintenance of their optimum temperature.

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