Diagnostics of Cars' Gas Supply Systems per Tightness Parameters as a Factor of Ensuring Fire Safety

A.R. Simonyan, R.M. Balayan, E.G. Karapetyan, V.A. Shaghoyan

Armenian National Agrarian University

arman.simonyan@anau.am, expert.balayan18@gmail.com, eminkarapetyan79@gmail.com, shagoyanv@mail.ru

ARTICLE INFO

ABSTRACT

In order to ensure fire and explosion safety during the operation of gas cylinder vehicles, the control and technical condition of the elements in the vehicle's power system, particularly one of the most important types of operational verification – technical diagnostics of the vehicle through identifying relevant methods and means has been considered in the current article.

It is recommended to install leak detectors with built-in gas flow control sensors in the design of the power supply system of a compressed gas vehicle, which will ensure the detection of gas leaks in the event of depressurization of the car's gas equipment reducing the number of accidents.

Introduction

The persistent increase of the car numbers leads both to a sharp reduction in oil reserves – raw material for fuel production- and the accumulation of toxic substances released from exhaust gases in the environment (Simonyan, 2010). Expanding the material base of liquid fuel and simultaneously reducing the toxic impact on the ecology can only be done at the expense of the so-called unconventional or alternative fuels. Gaseous hydrocarbon fuels, which are environmentally friendly motor fuels, are most widely used in road transport (Yerokhov, 2012). The cost of gas fuel is two to three times lower than the cost of gasoline and diesel fuel, and their raw material reserves exceed those of oil. These factors determine the use of

gas fuel in road transport and large-scale imports of gas cylinder vehicles and the massive retrofitting of gasoline and diesel engines with a gas fuel system without structural changes to the basic models. However, the transition to the use of gas fuel in cars requires implementation of additional works for the installation of gas supply systems, including gas cylinders installation, their maintenance and repairs. The use of gas fuel in automobile transport raises the requirements for maintaining fire safety in the process of operation of gas cylinder automobiles.

In order to meet those requirements, it is necessary to develop such a feeding system, which will enable to warn and exclude the leakage of engine gas fuel during the operation of the car, avoiding possible accidents.

Materials and methods

The advantage of efficient use of gas cylinder automobiles largely depends on the timely and high-quality technical diagnosis in the technical condition of their gas supply systems (RD 3112199-1069-98). One of the main operations of technical fault diagnosis of gas cylinder automobiles is checking the tightness of gas equipment connections, because in case of gas leakage from the fuel system, the probability of fire (explosion) increases significantly. The development and implementation of a safely combined gas supply system with built-in gas flow control sensors that detect (warning) the possible leakage of gas from the gas supply system is of great importance for ensuring the fire safety of gas cylinder vehicles.

Results and discussions

To achieve the main goal of the current work a task has been set up to develop a power supply system so as to ensure the operational safety of gas cylinder automobiles. In order to ensure the safe operation of the cars in the motor vehicle fleet, the inspection of technical condition, especially the operational inspection is of special significance.

One of the important types of operational inspection in the field of technical exploitation is technical fault diagnosis. Technical diagnosis enables to determine the internal technical condition of the car's units, nodes, systems and mechanisms without dismantling at the given time with external and built-in technical means. It solves the problems of car and its units troubleshooting, as well as those of predicting the residual stock.

As studies show (Bazikyan, et al., 2008, Dyukov, 1995), significant research work has been done in the direction of fault diagnosis of fuel system equipment in order to meet the requirements of fuel economy and pollution protection from gases emitted into the environment during the operation of automobiles, but in view of gas cylinder supply system such researches are completely absent, though the technical condition of that system also significantly depends on engine parameters such as: power, fuel consumption, operation quality, stability of work at low rpm during idle time, dynamics of the car, toxicity of exhaust gases, etc.

During the operation of vehicles with a gas cylinder supply system violation of the tightness in the reducer's first and second stage valves, as well as in the reducer's diaphragm occurs, as well as violation in the second stage valves and in the adjustment of the unloading device spring and shut-off of the high-speed valve in the waste pipe of the gas cylinder is recorded. Therefore, the advantage of efficient use of cars powered by compressed gas largely depends on timely high-quality diagnosis of the technical condition of their gas supply system.

The most common method of checking the technical condition of cars' gas systems is the diagnosis according to the hermetic parameters of working volumes. The point of that method is the detection and quantitative evaluation of gas leaks upon the working volumes of the system (from the gas cylinder, gas reducers, craters, fuel filters, test-measuring devices, as well as connections of all elements of the gas system). When using this method, the subjectivity of the test dominates, that is, the detection of a gas leak due to the neuroleptic abilities (by smell, hearing and vision) of a person – a driver or a checkpoint mechanic, releasing the car on the line and returning it.

Among the existing technical means of checking the tightness of the gas system are the stationary installation TsPKTB-K263, the portable signaling devices "Methane-99", "MSM-2K", "MT-3" (RA Patent 3243A, Simonyan, et al., 2022).

The use of compressed gas – methane or propane-butane mixture – sets special requirements for the safe operation of automobiles (RD 03112194-1095-03, GOST 27577-87).

Each such vehicle, especially if it is a passenger bus, for example, should preferably be equipped with continuous gas leak detection devices. Any motor transport company of the Republic of Armenia, which operates a motor vehicle with a re-equipped gas fuel system, is obliged to have gas flow control indicators for the implementation of regulated checks of the hermeticity of the gas cylinder equipment, because the use of gas fuel increases the fire safety requirements during the operation of motor vehicles.

One of the main processes of diagnosing the faults of gas cylinder automobiles is checking the tightness of connections of all elements in the gas system. To ensure such processes, the authors propose a safe combined gas supply system with built-in gas flow control sensors (Internal combustion engine combined supply system. RA Patent No. 3242A), the scheme of which is shown in the introduced Figure.
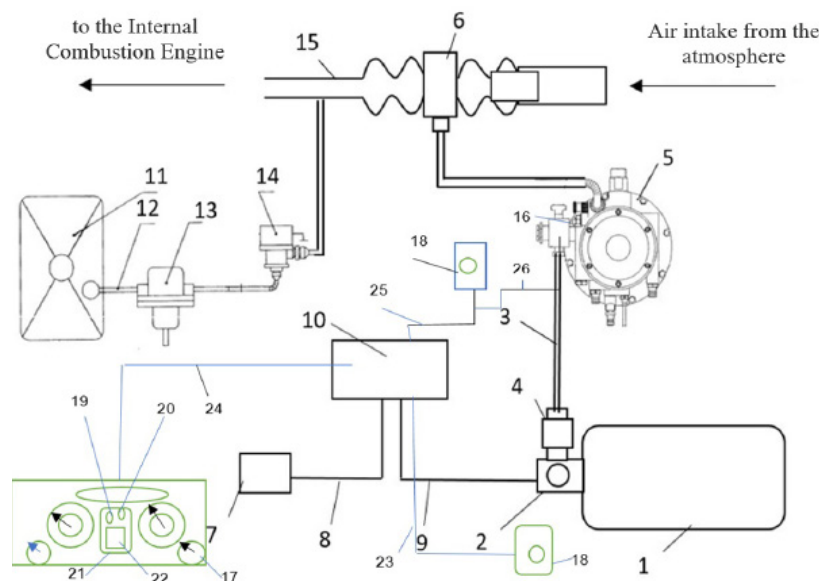
Figure. Diagram of the combined system for safe gas supply *(composed by the authors)*.

The system consists of a high-pressure gas cylinder (1), a mechanical valve (2) and a gas electromagnetic valve (GEV) (4) located between the gas pipe (3), which is calculated to ensure operation at a pressure of 29 MPa and is structurally integrated with the gas filter via one junction, two-stage low-pressure reducer-heater gas reducer (5) and crater (6), of the high-pressure reducer (HPR) (16), which reduces the gas pressure from 20 MPa to 0.5-10.2 MPa, of the shock sensor (SS) (7), which (GEV, HPR, SS) are connected to the electronic control unit (signal processing unit received from pulse sensors) (10) by electrical wires (24), (8) and (9), respectively, which provides sound and light signaling on the control panel in the driver's cabin, disconnection of the gas solenoid valve from the engine stopping, blocking of the engine start, if the pipe of gas filling station is not disconnected from the filling station, as well as transition from gas to gasoline or vice versa, of the gas tank (11), the gas pipe (12), fuel filter (13) electronic gas pump (14) and throttle tube (15), as well as of the sensors (18) that detect the amount of gas and smoke in the atmosphere located under the engine cover and in the passenger compartment, which are connected to the microprocessor control unit and the devices by wires (23) and (25), respectively to the gas leak alarm (21) located on the panel (17), which in turn consists of a liquid crystal

display (LCD) screen (22), LED (19) and a speaker (20).

The system works with the following principle:

In case of gas leakage from the gas cylinder (1) of the vehicle operating via combined supply system or from the gas pipe (3) and upon the connections of two-stage reducer-heater (5) and also in case of smoke, the sensor (18), which detects the amount of gas and smoke in the atmosphere, with a set of wires (23, 25, 26) sends an impulse to the microprocessor block (10), which in turn sends a signal through a set of wires (24) to the gas leakage alarm (21) located on the device panel (17), as a result of which the LED (19) lights up, the speaker (20) works and the gas and smoke amount of the atmosphere appears on the liquid crystal display (LCD) screen (22). Fixing the information about the possible leakage, the system closes the gas electromagnetic valve (10) by means of the microprocessor block (10) and the wire (9), stopping the gas flow from the gas cylinder (1), as a result, automatically converting the gas supply system to gasoline.

With the support of recommended system, it becomes possible to alarm with all available options during the gas leakage of a car with a combined power system, which will create an opportunity to possibly eliminate fire explosion situations as a result of appropriate measures.

Conclusion

A safe combined gas supply system with built-in gas flow control sensors that detect (warning) the possible leakage of motor gas fuel from the gas supply system per the fault diagnosis in hermeticity parameters upon the working volumes in the process of gas cylinder car operation has been recommended, the introduction of which will entail to the reduction of accident numbers (including fires).

References

1. Bazikyan, N. A., Balayan, R. M., Simonyan, A.R., Sargsyan, N.S. (2008). A method of Increasing the Eeffective Power of Gas Cylinder Engines. Agrogitutyun No. 3-4, Yerevan, - pp. 180-182.

2. Combined Power System of Internal Combustion Engine with Gas Import. RA Patent Number 3243A.

3. Dyukov, E. (1995). Ecological Safety - a Strategic Direction / E. Dyukov // Road Transport. - № 4, - pp. 40-42.

4. GOST 27577-87. Natural Compressed Gas for LPG Vehicles. - M.: Publishing House of Standards, 1987. - 24 p.

5. Internal Combustion Engine Combined Power System. RA Patent Number 3242A.

6. RD 03112194-1095-03. Guidelines for Organizing the Operation of LPG Cars Working on Compressed Natural Gas. 2003.

7. D 3112199-1069-98. Fire Safety Requirements for Enterprises Operating Motor Vehicles on Compressed Natural Gas. 1998.

8. Simonyan, A. (2010). Natural Gas as Motor Fuel of the 21st Century. "Transport, Ecology-Sustainable Development" XVII Scientific and Technical Conference with International Participation, ECO VARNA 2010.

9. Simonyan, A.R., Mosikyan, K.H., Asoyan, S.A., Shaghoyan, V.A. (2022). Improving Fire Safety System in Gas-Powered Vehicles. ANAU, Agriscience and Technology, - N 1 (77), - pp. 28-31. https://doi.org/10.52276/25792822-2022.1-28.

10. Yerokhov, V.I. (2012). Gas Cylinder Cars. "Design, Calculation, Diagnostics". M.: Hotline-Telecom, -206 p.