

EXPERIMENTAL RESEARCH OF FUEL EFFICIENCY AND EMISSIONS OF A DIESEL ENGINE USING HYDROGEN-CONTAINING GAS

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Abstract. The paper presents the relevance of research of the possibility to reduce fuel consumption and emissions of polluting substances. It was found out the possibility of using hydrogen-containing gas in diesel engines in order to reduce fuel consumption and exhaust gas emissions. The current state of using of hydrogen-containing gas in internal combustion engines was analyzed in the scientific work. The paper use the preliminary results of stand tests of a diesel engine regarding to its fuel efficiency in terms of fuel consumption per hour and specific fuel consumption using hydrogen-containing gas in the fresh air charge. It was calculated the road fuel consumption of the steady traffic of the bus "BOHDAN". The bus is equipped with a chinese Dong Feng diesel engine. The theoretical and experimental methodology, for researching the environmental indicators of diesel engine using hydrogen-containing gas, was developed. It was presented the developed equipment for conducting experimental research in the paper. It was found out that the using hydrogen-containing gas in Dong Feng diesel allows to increase fuel economy and reduce emissions of polluting substances.

INTRODUCTION

Internal combustion engines are still quite widely used in the world. It is confirmed by their positive indicators. Internal combustion engines will still power motor vehicles, industry etc [1-3]. However, the using of internal combustion engines is the cause of a number of problems. First of all, this is the depletion of oil resources [4-5]. Another global problem is environmental pollution. Pollutants produced by engines are a significant source of environmental pollution, so the study of engine emissions is very important [6-8]. The problem of global climate change is also partly caused by the using of internal combustion engines [9].

Global trends leave the use of renewable and environmentally friendly alternative fuels as key tasks to supply energy needs. This is especially the field of automotive transport [10]. Besides, the development of internal combustion engines posed new challenges. The United Nations also has a goal to provide clean energy for all and solve challenges of climate change [11-12].

One of the ways to solve the above-mentioned problems is to use a renewable energy sources [13]. There are different types of renewable energy sources in the world. A large number of different types of renewable energy sources is due to the problem of constant population growth and living standards [14]. One of the well-known type of renewable energy sources is hydrogen-containing gas. The analysis confirmed the prospects of using hydrogen-containing gas in diesel engines in many countries of the world [15-17]. Therefore, scientific research of the using of

hydrogen-containing gas in the Dong Feng diesel engine is an important task today. The goal of the paper is to improve fuel economy and reduce exhaust gases into the atmosphere.

METHODOLOGY OF SCIENTIFIC EXPERIMENTAL RESEARCH

Thanks to previous scientific works, the main initial data for further research, which are outlined in this paper, were obtained. In the paper a tendency to decrease the specific fuel consumption of the Dong Feng diesel engine was observed. The optimal dose of hydrogen-containing gas in a fresh charge was established, taking into account the minimum of specific fuel consumption. [18]. A special device (Fig. 1), for the production and using of hydrogen-containing gas, was designed at the department of vehicles and technology for their operation in the Cherkasy State Technological University [19]. The technical characteristics of the electrolyzer are shown in table 1. The electrolyzer was equipped with the necessary elements to supply hydrogen-containing gas to the internal combustion engine [20]. Experimental studies have shown that the minimum productivity of the electrolyzer is 8.8 liters per hour. The maximum productivity of the device is 27.9 liters per hour.



FIGURE 1. Device for production of hydrogen-containing gas (Electrolyzer)

TABLE 1. Technical characteristics of the electrolyzer

Name of the parameter	Parameter value
Operating voltage, V	12
Operating current, A (min-max)	1-12
Working fluid	solution of caustic soda in water
Number of working plates	13
Mass, kg	9

Dong Feng diesel (CY4102BZLQ) was used to study fuel economy and exhaust gases into the atmosphere. This diesel is quite common in "BOHDAN" A-091 buses, which are still used in the city of Cherkasy (Ukraine) for passenger transportation. The simulation of the diesel engine operation was provided at the classic test stand of the department of vehicles and technology for their operation (Cherkasy State Technological University). The

CY4102BZLQ series diesel engines are turbocharged engines that are designed and manufactured by improving the CY4102BZQ series diesel engines. Such diesel engines were installed on buses of models A-081, A-082, A-091 and A-092, trucks of such series as NR, NQR (manufactured by the "BOHDAN" Corporation), trucks of models 1044Y, 1065F (Groz Fox and Groz Baw), which are quite common on the highways of Ukraine and far away its borders.

Hydrogen-containing gas added into the intake pipeline to the air charge. During the experimental studies, a constant maximum addition of hydrogen-containing gas was used. Fuel consumption per hour was determined by volumetric method. To determine specific fuel consumption, a classic formula was used, taking into account fuel consumption per hour. In order to conduct theoretical studies of road fuel consumption, specific fuel consumption and fuel consumption per hour were determined.

The road fuel consumption (Q_s) of the constant "BOHDAN" A-091 bus movement was determined by theoretical methods, taking into account its speed, numbers of the transmission and the frequency of crankshaft rotation etc. Calculations were made taking into account the addition of hydrogen-containing gas to the fresh charge ($Q_s H_2O_2$).

EXPERIMENTAL DATA AND RESULTS

As a result of the stand tests, polynomial dependencies were obtained. The resulting polynomial dependencies were used to determine the road fuel consumption of the diesel engine installed on "BOHDAN" A-091 buses. Dependencies of fuel consumption on the road from the speed of the bus in the steady mode of movement is shown in figure 2. The results of the calculated dependences prove that using polynomial models it is possible to predict the improvement of the fuel efficiency of a diesel engine that operates on hydrogen-containing gas. Estimated road consumption of diesel fuel running on hydrogen-containing gas, decreased by 5%.

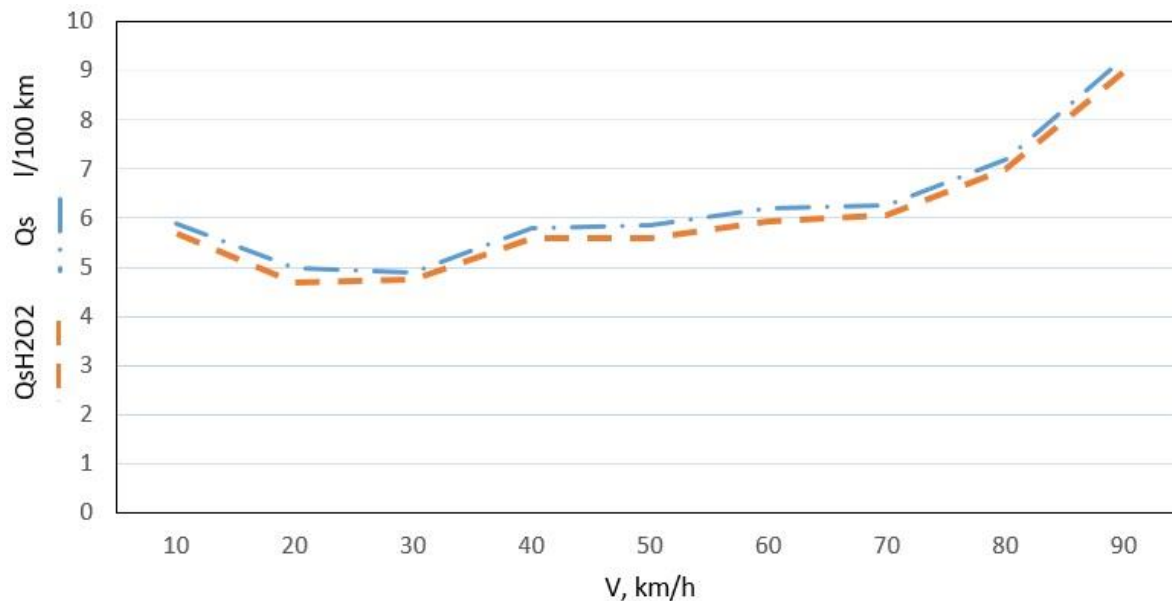


FIGURE 2. Road fuel consumption depending from the speed of the bus

The studies of exhaust gases into the atmosphere provided the determination of mass emissions of their specific components. It was researched the most polluting substances of diesel exhaust gases. That is, mass emissions of specific polluting substances have been determined. The initial data for the determination of mass emissions were the concentrations of each polluting substance of the exhaust gases. The concentrations of the most polluting substances were established by the way of experimental stand diesel tests. The concentrations of polluting substances in diesel exhaust gases were researched at the department of automobiles and technology of their operation in Cherkasy State Technological University.

The generalized results are represented in the total mass emissions of polluting substances reduced to carbon monoxide. Theoretical research of mass emissions of polluting substances allow to show a comparative dependencies of engine operation on diesel fuel and with the addition of hydrogen-containing gas to the fresh air

charge (Fig. 3). Fig. 3 shows, that the addition of hydrogen-containing gas to the fresh charge allows to reduce the total mass emissions of polluting substances up to 12% (maximum engine load mode).

As a result of theoretical and experimental studies of the CY4102BZLQ diesel engine, certain differences in the use of hydrogen-containing gas have been established. This requires additional research on diesel engine control parameters in order to obtain greater efficiency in the use of hydrogen-containing gas in internal combustion engines. In diesel engine, that is tested, minimal parameter settings can be made to adapt the combustion process to the use of hydrogen-containing gas. Appropriate adjustment actions can be easily made using the design features of the Dong Feng diesel engine. We are talking about the adjustable fuel injection advance angle. This parameter, for example, is regulated within certain limits with the help of a fuel pump. But this is a task that will be carried out in future research.

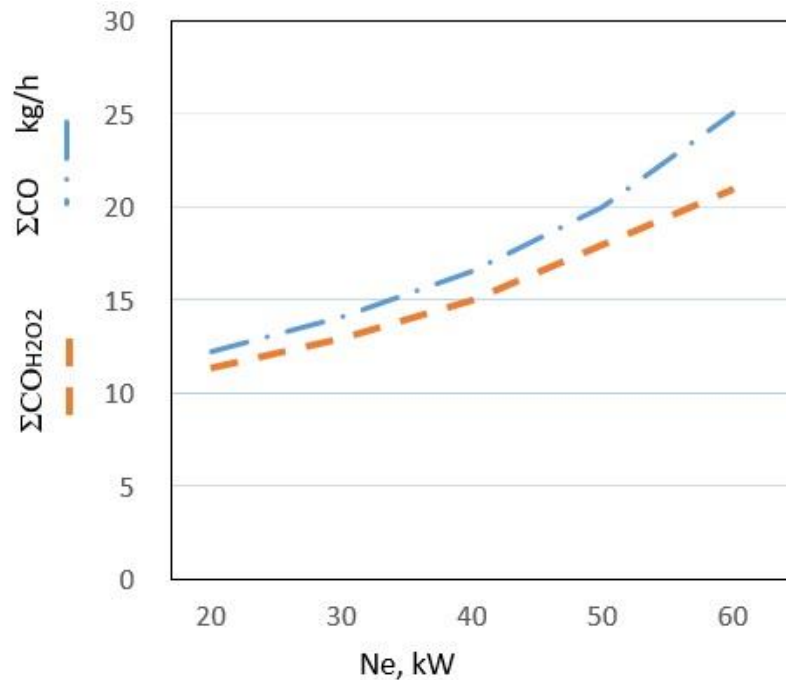


FIGURE 3. Total mass emissions of polluting substances

CONCLUSION

The analysis showed a positive perspective for the use of hydrogen-containing gas in internal combustion engines, particularly in diesel engines. The prospects for the use of this type of fuel are determined by the main world problems. We are talking about depletion of natural resources and global climate change.

A special device (electrolyzer) was developed to conduct experimental studies of the influence of hydrogen-containing gas on fuel economy. The research of the fuel economy and exhaust gas emissions of the Dong Feng diesel, powered by hydrogen-containing gas, has shown its effective use. The research in this way allows partially solve the mentioned world problems.

According to the conducted research, the estimated fuel consumption on the road in the "BOGDAN" bus, equipped with a diesel engine running on hydrogen-containing gas, decreased by 5%. The addition of hydrogen-containing gas to the fresh charge allows to reduce the total mass emissions of polluting substances up to 12%.

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