ISSN: 2181-1067 Journal homepage: www.summusjournals.uz ISSN: 2181-1253

International scientific and technical journal
INNOVATION TECHNICAL AND TECHNOLOGY
Vol.2, №.2. 2021.

PERSPECTIVE USE OF HYDROGEN FOR AUTOMOBILE ENGINES

Ismatov J.F.[1*], Khakimov J.O.[1], Mirzaev A.A.[1]

[1]*Tashkent state technical university, 100095, 2 str. University, Tashkent, Uzbekistan*

Abstract. The Presidential Decree N PP-4422 of August 22, 2019, titled "On accelerated steps to increase the energy performance of sectors of the economy and the social sphere, the implementation of energy-saving technologies, and the production of renewable ene sources," outlined a detailed plan aimed at achieving tactical and strategic goals. Accelerated modernization, technical and technological re-equipment of businesses, implementation of new flexible technology, increasing business productivity through austerity, transition to international quality standards, and widespread introduction of innovative technologies [1, 2]. Transportation is one of the key elements of modern civilization. Its condition and prospects for development depend to a great extent on the possibilities of supplying transport power plants with fuel. The depletion of liquid hydrocarbon fuel reserves and the problems of environmental pollution may put mankind before the alternative - either to reduce transportation or to find new ways of energy supply for transport. Prospects for solving the fuel problem of transport, the main power plant of which is an internal combustion engine, are related to the use of hydrogen in the future.

Key words: hydrogen, transportation, methane, ecology, car, engine, fuel, gasoline, environmental performance.

Methods

There are no doubts about the use of hydrogen as fuel for internal combustion engines either in its pure form or as an additive to the main hydrocarbon fuel. Hydrogen as an additive to the main hydrocarbon fuel has a number of advantages: good ignitability in the mixture with air, ensuring easy engine start at almost all possible ambient temperatures; high antiknock resistance, allowing operation at high compression ratios; high combustion rate and completeness, which allows to bring the real cycle of ICE with spark ignition to the ideal one with heat input to the mixture at constant volume, i.e., increase cycle efficiency. The addition of hydrogen to gasoline reduces the emission of such harmful emissions as CO, CO_2 and CH, as evidenced by numerous publications [3, 4, 5].

Prospects of hydrogen application for automobile engines are determined, first of all, by ecological purity, unlimited and renewable raw material reserves, as well as unique motor qualities, which opens up the possibility of its wide application in modern engines without significant design changes.

Results and discussion

Hydrogen as a fuel for internal combustion engines is determined by its energy and environmental performance and motor properties. Hydrogen has a number of features that distinguish it from other conventional and alternative fuels for internal combustion engines. While hydrogen is one of the most energy-dense fuels, with a calorific value of $120\text{-}10^3$ kJ/kg, it takes 2.3 times more air to burn. Since hydrogen has a low density (0.089 kg/m^3), the calorific value of a hydrogen-air mixture of stoichiometric composition is lower than that of conventional fuel-air mixtures. The energy strength of the internal mixture forming phase is increased by 12 percent or more. Due to the propensity for self-ignition at the inlet, detonation, and high nitrogen oxide emissions, the power value of a hydrogen engine is determined by the ability to use the area of stoichiometric composition of mixtures. Motor properties of hydrogen provide the ability to form a homogeneous mixture, exclude the formation of a liquid film in the intake path. In the internal mixture formation process the formation of a homogeneous mixture is more complicated. By mass energy intensity hydrogen exceeds traditional hydrocarbon fuels by 2.5-3 times, alcohols by 5-6 times, ammonia by 7 times. It has a higher diffusivity, higher combustion rate and a wide ignition range. The ignition energy of hydrogen is an order of magnitude lower than that of hydrocarbon fuels. Hydrogen-air mixture ignites steadily in a wide range of concentrations, from α=0,2 to α=10. This provides the ability to operate in a wide range of speed modes when regulating power by qualitative and quantitative methods [6,7,12].

There are very simple systems used to produce hydrogen and oxygen by electrolyzing water. The point is that the technology is used to produce enough gas without additional chemicals or erosion of the electrodes. You can try to make electrodes out of copper, but this material reacts with water and releases a lot of contaminants, so this option is poorly suited.

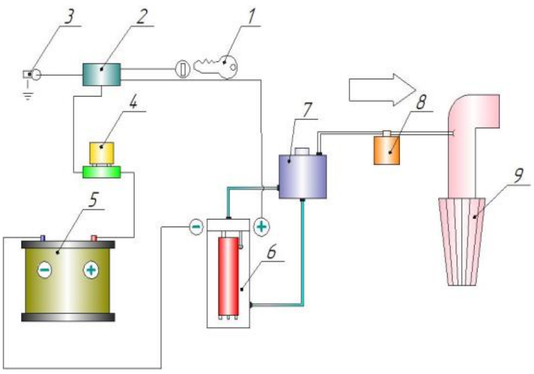

Fig.1 Schematic diagram of the hydrogen electrolyzer.
1- Key, 2 - Relay, 3 - Mass, 4 - Fuse, 5 - Accumulator, 6 - Electric alternator, 7 - Reservoir, 8 - Moisture separator, 9 - Air filter

Since stainless steel does not react as easily as copper in the electrolysis process, we suggest using it to make the electrodes. The key issue here is locating high-quality stainless steel. The charge that passes through the water determines how much gas is emitted. As a result, the higher the current, the more gas is generated. The distance between the electrodes for this should be as small as possible, but the gas bubbles should move easily between them. A schematic diagram of the hydrogen electrolyzer is shown in Fig. 1. For the plates we recommend to use also good stainless steel, which has minimal risk of corrosion. Stainless is not as good at conducting electricity as copper, so electrode plates are created from sheets about 2 mm thick. This will reduce the resistance. The higher the quality of the metal, the harder it will be for you to make the electrodes (the material is harder to cut). We recommend making the electrode plates in layers, and the distance between them can be adjusted with nylon washers or washers of some other dielectric material. The plates should be placed in a variable position so that the plus plates alternate with the minus plates [10,11,13].

Studies aimed at using hydrogen as a fuel for internal combustion engines are structured in such a way that a gradual substitution of traditional fuels with hydrogen is carried out. In this sequence we can distinguish three main stages: application of hydrogen to traditional fuels in the form of additives; partial substitution of traditional fuels with hydrogen and application of hydrogen in its pure form, which is the most interesting. A comprehensive list of research works by domestic and international writers testifies to the solution of these issues, in which hydrogen is used as an additive (additive), a partial replacement of conventional and alternative fuels on the basis of spark-ignition engines, and for compression-ignition engines.

Hydrogen as a fuel for internal combustion engines is characterized by a high velocity of the flame front propagation, which can exceed 200 m/s. This speed can cause a pressure wave moving in the combustion chamber at a speed of over 600 m/s. The high combustion rate of hydrogen-air mixtures has a positive effect on increasing the efficiency of the working process, at the same time, high values of the maximum pressure and cycle temperature, high rigidity of the hydrogen engine working process are predetermined.

A higher rigidity ((dp/dϕ)max) of the operating process is defined by engine operation with partial substitution of the main fuel up to 40%-60%, i.e. engine operation with an internal process of mixture forming, when hydrogen is fed directly into the cylinder. The analysis shows an improvement in fuel efficiency while maintaining engine power, reduction of harmful substances from exhaust gases [8,9,14]. At the same time, the rigidity of the working process and the maximum combustion pressure increase significantly. Thus, at 50% replacement of gasoline-air mixture by hydrogen, the rigidity of the working process ((dp/dϕ)max) increases by more than 100%, and the maximum pressure Pz by 30%. These values are explained by the fact that the motor properties of hydrogen and the high combustion rate of hydrogen determine the first phase of heat generation x1, which increases by 75%. It is determined from the equation describing the two-phase heat release process

$$x = x_1\left(1 - e^{-\left(\frac{k_1-1}{k_1}\right)*\left(\frac{\varphi_c}{\varphi_1}\right)k_1}\right) + x_2(1 - e^{-\frac{k_2-1}{k_2}*\left(\frac{\varphi_c}{\varphi_2}\right)k_2})$$

The first step of hydrogen combustion is determined by its motor properties, which improves fuel efficiency while also determining the growth of (dp/d)max and P_z. The kinetic mechanism determines the first phase of combustion, and the diffusion mechanism determines the second phase. The excess air ratio at the hydrogen fraction of 50%, according to the load characteristic, increases by 12-15%. Depending on the share of hydrogen to diesel fuel by mass in the working mixture r = G_n/G_t, the value of x_1 is determined by

$$x_1 = \frac{x_{1o} + \left(\frac{H_{UH}}{H_{U б}}\right)r}{1 + \left(\frac{H_{UH}}{H_{U б}}\right)r}$$

where H_{UN} and H_{Ub} are the lower calorific values of hydrogen and gasoline, respectively; x1o is the fraction of heat released in the first phase during operation with gasoline of the base ICE.

Conclusions

Hydrogen is an environmentally friendly fuel because its combustion produces only water.

The use of hydrogen as a fuel is possible in a variety of conditions, which can provide a significant contribution to the world's energy industry when fossil fuel resources are close to complete depletion. Compared to gasoline and diesel fuel, hydrogen is more efficient and less polluting.

A hydrogen generator (electrolyzer) for hydrogen production was created.

Improved engine economy, primarily due to the use of quality control and ensuring a more complete and timely combustion. When using low-octane fuels with optimal addition of hydrogen, an increase in fuel economy is possible due to an increase in the compression ratio;

Complete elimination of emissions of the main greenhouse gas - carbon dioxide and significant reduction of toxicity by reducing emissions of incomplete oxidation products. When operating on poor mixtures, emissions of nitrogen oxides are also low.

As an additive to gasoline and natural gas, such use of hydrogen can already give not only an economic effect, but also solve environmental problems, especially in large metropolitan areas.

References

1. Postanovleniye Prezidenta Respubliki Uzbekistan 22.08.2019 g. n pp-4422 Ob uskorennykh merakh po povysheniyu energoeffektivnosti otrasley ekonomiki i sotsial'noy sfery, vnedreniyu energosberegayushchikh tekhnologiy i razvitiyu vozobnovlyayemykh istochnikov energii.
2. Postanovleniye Prezidenta Respubliki Uzbekistan 10.07.2020 N q-4779 Uvelicheniye energoeffektivnosti ekonomiki i snizheniye zavisimosti ekonomicheskikh sektorov v toplivno-energeticheskikh produktakh.
3. Avtomobil'nyye dvigateli. M.G. Shatrov. Moskva. Akademiya. 2010g.
4. Lukanin V.N., Trofimenko Yu.V. «Promyshlenno-transportnaya ekologiya», M. Vyssh. shkola, 2003,273 s.
5. Novoselov S.V. Ispol'zovaniye vodoroda v kachestve motornogo topliva: Teploenergetika. - №2. - Moskva, 1996. - S.27-28.
6. Osobennosti raboty DVS pri ispol'zovanii vodoroda. Zh.F. Ismatov, S.M. Kodirov. TAYI khabarnomasi. №1, 2017y.
7. Yegorov B.V., Markachev Yu.Ye. Kolebatel'noye vozbuzhdeniye pri sverkhzvukovom gorenii vodorodo-vozdushnoy smesi i yego vliyaniye na kineticheskiye i gazodinamicheskiye protsessy. / Khimicheskaya fizika protsessov goreniya i vzryva T.1, Ch.1.: Chernogolovka, 1996. - S.24-26.
8. A.S. 1087681 SSSR, MKIF 02 V25/06. Sistema pitaniya. Dvigatelya vnutrennego sgoraniya/ Vagner V.A., Matiyevskiy D.D., Novoselov A.L. i dr. - №3556791/25-06; Zayavl. 29.08.83; Opubl. v B.I., 1984, №13.
9. A.S. 1455008 SSSR, MKIF 02 V69/04. Dvigatel' vnutrennego sgoraniya/ Novoselov A.L., Novoselov S.V., Sinitsyn V.A., Bryakotin M.E. – №4258070/25-06; Zayavl. 23.03.87; Opubl. v B.I., 1989, №4.
10. Vodorod kak dobavka k uglerodnomu toplivu. TADI. Nauchno-tekhnicheskaya konferentsiya. 20-21 maya 2016 g. Ismatov Zh.F., Boboyorov Z.M.
11. Matmurodov F., Sobirov B., Tulanov I., Mirzaabdullayev J., Khakimov J., Daminov O. Mathematical Modeling of the Transfer of Energy Forces from the Engine through Hydro Transmission and Hydro Differential to Executive Bodies. World Journal of Mechanics (Web of Science). USA, Scientific Research Publishing, 2019. P. 105-112.
12. Abdunabiyeva Noila Yusufjon qizi, “ENERGY-SAVING TEXNOLOGIES AND ALTERNATIVE ENERGY SOURCES”, STJITT, vol. 1, no. 1, pp. 90-93, Sep. 2020.
13. Matmurodov F.M., Daminov O.O., Mirzaabdullayev J.B., Hakimov Zh.O. Mathematical modeling of transfer of the moment from the engine to the executive mechanism. – Austria, Vienna. “East West” Association for Advanced Studies and Higher Education GmbH. European science review (Scientific journal), 2017. № 3–4. (March–April); P. 75-77.
14. Валиев М.Ш and Қосимов Х.Р, “РАЗРАБОТКА МЕТОДА ИНТЕГРАЛЬНОЙ ОЦЕНКИ ТЕХНИЧЕСКОГО СОСТОЯНИЯ ЦИЛИНДРОВ ДИЗЕЛЯ В ЭКСПЛУАТАЦИИ”, STJITT, vol. 2, no. 1, pp. 1-6, Jan. 2021.