Research of Conditions of Economic Efficiency of Use of Composite Gasoline-Hydrogen Fuel

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Abstract--- *In this paper, we consider the analysis of data obtained by additional supply of hydrogen to the internal combustion engine as an additive to gasoline. The article presents the results of a study of the operating conditions of a passenger car using hydrogen as an additive to gasoline and determines the fuel consumption on the route of 100 km. Analysis of studies on the use of composite gasoline-hydrogen fuel for changing fuel consumption showed that the economic effect is observed and is 14,400 sum per day; 432,000 sum per month; 5,184,000 sum per year per vehicle. The revealed conditions of economic efficiency showed that when using composite gasoline-hydrogen fuel, significant economic efficiency is possible when used in urban passenger (taxi) transport.*

Keywords--- *Composite Fuel, Hydrogen, Electrolier, Economic Effect, Gasoline-Hydrogen Fuel, Standard Coefficients, Experiment, Engine Efficiency Indicator, Fuel Injection Advance Angle.*

I. INTRODUCTION

Hydrogen has great prospects for the internal combustion engine, since it has an inexhaustible source of raw materials, and the heat of combustion of which is very high when loaded. Since the hydrogen diffusion coefficient is high, regardless of the method of supplying hydrogen to the cylinders in various ways creates a homogeneous mixture and in all operating modes of the engine makes it possible to evenly distribute it to the cylinders. [6]

A large number of experimental works are devoted to the use of hydrogen in an internal combustion engine as a composite gasoline-hydrogen fuel, performed by both Russian and foreign authors. However, all works are of a research nature and have not been brought to practical use. Studies show the effectiveness of hydrogen additives in reducing the toxicity of exhaust gases while increasing the efficiency of using composite gasoline-hydrogen fuel in air-fuel mixtures. The purpose of the experiment was to obtain real data during the experiment about the possibility of reducing fuel consumption with the addition of hydrogen with an assessment of its practical application.

Review of research results on the use of hydrogen in an internal combustion engine as a composite gasoline-hydrogen fuel.

Review of the results presented in Gennady Borisovich Talda dissertation

The calculation of the real cycle with the difference in hydrogen additives to gasoline showed that the main factor in reducing the engine efficiency when increasing the mass fraction of hydrogen from 0.03 to 0.10 is considered a significant increase in relative heat losses during dissociation of combustion products. The calculated

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study of the theoretical engine cycle showed that the system of influence of adding hydrogen to gasoline on the combustion process is expressed in an increase in the concentration of active elements in the area of combustion products. It is established that the efficiency of the theoretical cycle practically does not depend on the composition of fuel-hydrogen fuel compositions, but increases significantly with the depleted composition of the mixture. [10]

Review of the results presented in Viktor V. Rumyantsev's dissertation

In the work of Viktor V. Rumyantsev, it is presented that when a carburetor engine is running in a fuel-air mixture, the excess air coefficient is usually in the range α=(0.8-1.2). This is explained by the narrow concentration limits of ignition of the fuel-air mixture. Ensuring high fuel efficiency of the carburetor engine is acceptable in the case of fuel with wide concentration limits of ignition. According to research data [10], a 5% addition of hydrogen (according to mass) to gasoline made it possible to save the most power of the GAZ-24 engine while reducing fuel consumption by 30%. With absolute throttle opening and equal power, the specific fuel consumption when working with a 5% hydrogen addition decreased by 11.5% (from 340 g / kWh to 297 g / kWh). [11]

Review of the results presented in Leonid Bortnikov thesis due to the expansion of the limits of stable combustion of fuel assemblies with hydrogen additives, stable engine operation was provided in the studied modes at the excess air coefficient equal to α = 2.2-2.4. the relative amount of hydrogen was 30% of the gasoline consumption at idle at n=850 rpm and 50% for n=2185 rpm and recycled exhaust gases =0.2 MPa. Studies of the effect of hydrogen additives on the working process of recycled exhaust gases have shown that the selected engine operating mode (recycled exhaust gases=0.2 MPa, n=2185 rpm) allows you to get the ratio of hydrogen-the amount of recycled gases, in which the consumption of gasoline is reduced, in particular, by 7% compared to the initial level (recycled exhaust gases =0). [12]

II. MATERIALS AND METHODS

The program included studying the features of the working process and removing the main characteristics of the serial engine using conventional fuel and the engine using a hydrogen additive to gasoline.

One of the main factors that affect the flow of the working process and, as a result, the efficient and economical operation of the engine, is the angle of advance of the fuel supply (injection). If the lead angle is too high, fuel injection starts at a relatively low pressure and low temperature, which leads to an increase in the ignition delay period, accumulation of a large dose of evaporated fuel by the beginning of the rapid combustion phase, and an excessively rigid combustion process.

The purpose of the tests is to study and determine the operating conditions of a passenger car with a gasoline-hydrogen fuel mixture as an additive and determine the fuel consumption per 100 km of travel.

The object of testing is a passenger car running on gasoline and hydrogen as an additive on a route of 100 km. when testing a passenger car running on gasoline with the addition of hydrogen, its load corresponded to the actual operating conditions.

To obtain statistical data on the fuel consumption of a passenger car running on gasoline and a hydrogen additive of gasoline, control measurements of fuel consumption are carried out. Before testing, the technical condition of the

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vehicle is checked.

The test procedure was performed on the basis of O'zDst 1.6:2003 GSS Uz, normative documents, General requirements for construction, presentation, design, content and designation, O'zdst 8.016: 2002. The method of measurements, MI-2377-98. Development and certification of measurement methods. - M.: VNIIMS, 1998. – 31 c. [1,2,3,4].

Tests are performed on vehicles with serviceable, sealed and verified speedometers. Vehicle management should be carried out in the same way as in ordinary operation. During testing, a survey of operating conditions is performed, a survey report is drawn up, in which data necessary for further calculation of standard coefficients are entered:

- Total mileage on the route;
- Number of forced stops on the route;
- Number of regulated and unregulated intersections on the route;
- Number of turns;
- Number of ascents and descents;
- Speed limits;

The driver, together with the contractor conducting the inspection, must make sure that there are no damages, leaks of oil, cooling and shock-absorbing fluids, check the filling of the engine with the coolant and oil recommended by the manufacturer, fill the full tank to the neck, and perform all other necessary work performed during daily maintenance. In the course of work, they are also required to carefully conduct a control inspection and make sure that the above-mentioned damages are not present.

Determination of the amount of spent gasoline is established by the results of measurements of the following values:

- Fill the full tank up to the neck and mark the mark before starting the measurement;
- At the end of the test, the amount of fuel consumed is measured by adding gasoline to the gas tank to the mark on the neck;
- Ambient temperature;
- Distance covered during the test;
- Time of trial.

The applied measuring instruments must meet the requirements listed in table 1 and have passed state verification in accordance with the established procedure. The measuring device must be installed and fixed in a place where its scale is easily visible to the tester. The ambient temperature sensor must be protected from direct sunlight and must not touch hard surfaces.

Note: the Tests should be carried out at: wind speed not exceeding 3 m / s, no precipitation, air temperature from -5 to +25 0C, atmospheric pressure from 730 to 760 mm Hg. St, atmospheric humidity is not higher than 90%.

The method of measuring the amount of gasoline consumed during the test is to determine the change at the end

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of the test by adding gasoline to the gas tank to the mark.

Table 1: List of Measurements Performed

№	Name of the measured value	Unit	Designation	Recommended devices		
				Name	Accuracy class	Measurement limit
1	The temperature of the gas (ambient air)	^{0}C	t_2	Meteorological glass thermometer GOST 112	1.0	-10-0+100
2	Time of trial	sek	T	Stopwatch GOST 5072	0.5	–
3	The mileage of the car during the test	km	S	Speedometer GOST 12936 (ST SAV 48657)	0.5	–

The amount of gasoline consumed during the test is determined by the formula

$$Q_{б} = Q_{п} - Q_{пд},\ l \qquad (1)$$

Where, $Q_{б}$ is the amount of fuel consumed, l

$Q_{п}$ – volume of the full fuel tank to the neck, l

$Q_{пд}$-residual fuel in the tank during the test, l

Example: during testing of a car with gasoline, the amount of fuel consumed:

$$Q_{б} = Q_{п} - Q_{пд} = 46 - 38{,}7 = 7{,}3\ l;$$

During testing of a car with the addition of hydrogen to gasoline the amount of fuel consumed:

$$Q_{б} = Q_{п} - Q_{пд} = 46 - 40{,}3 = 5{,}7\ l;$$

By determining the Q_B, knowing the vehicle's mileage S and the useful work performed W, you can calculate the mileage or transport fuel consumption:

$$Q_n = 100 \cdot \frac{Q_{б}}{S}, \qquad \frac{м^3}{100\ km} \qquad (2)$$

$$Q_{т} = \frac{Q_{б}}{W}, \qquad \frac{м^3}{т \cdot km} \qquad (3)$$

Where, QB-fuel consumption, l;

S-vehicle mileage, km;

W – completed useful work, t*km.

Table 2: Results of Fuel Consumption Measurements

Fuel	№ trips	The length of the trip, km	Indication of fuel level, l		Direction of movement	Actual fuel consumption per mileage, l / 100 km*	Actual fuel consumption per mileage, l / 100 km**
			before the test	at the end of the test			
1	2	3	4	5	6	7	8
Gasoline	1	100	46	38,81		-	7,29
	2	100	46	38,69		-	7,31
	Average.					-	7,3
Gasoline with hydrogen	4	100	46	40,32	Tashkent	-	5,68
	5	100	46	40,28	Chirchik	-	5,72
	Average.				Tashkent	-	5,7

Note:

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* the rate of fuel consumption with the use of a heater.

**fuel consumption rate without using a heater.

Table 2 shows the results of fuel consumption measurements on the route 100 km "Tashkent – Chirchik-Tashkent" and in the city of Chirchik of the car.

On the basis of the initial data obtained during the control measurements of fuel consumption, a generalized table is compiled, in which the following data are entered:

- The registration number of the subject vehicle, its grade (model);
- Total mileage based on speedometer readings in kilometers;
- Actual fuel consumption in liters;
- The value of the calculated actual fuel consumption in liters per 100 kilometers.

The results of processing tests on the route "Tashkent – Chirchik-Tashkent" for the car are shown in table 3.

Table 3: The Results of the Processing Tests

Fuel	Average flow rate	Deviation from the average value	
Gasoline	7,29	-0,1	0,01
	7,31	0,1	0,01
Gasoline with hydrogen	5,68	-0,2	0,04
	5,72	0,2	0,04

With gasoline $\overline{x} = 14{,}4 : 2 = 7{,}2$ l/100 km

Gasoline with hydrogen $\overline{x} = 11{,}4 : 2 = 5{,}7$ l/100 km

Mean square deviation: $\sigma = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \overline{x})^2}{n}} = \sqrt{\frac{0{,}02}{2}} = \sqrt{0{,}01} = 0{,}1$ l/100 km

Gasoline with hydrogen $\sigma = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \overline{x})^2}{n}} = \sqrt{\frac{0{,}08}{2}} = \sqrt{0{,}04} = 0{,}2$ l/100 km

Dispersion: $\sigma^2 = \frac{\sum_{i=1}^{n}(x_i - \overline{x})^2}{n} = \frac{0{,}08}{2} = 0{,}04$

The average square error of the measurement result or the standard of an individual measurement is determined:

$$S = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \overline{x})^2}{n-1}} = \sqrt{\frac{0{,}08}{1}} = \sqrt{0{,}08} = 0{,}282$$

Accuracy rate: $\frac{S_{\overline{x}}}{\overline{x}} * 100\% = \frac{0{,}2}{7{,}2} * 100 = 0{,}27$ %.

Therefore: – a trust boundary:

With gasoline: Iн1=7,2–0,01=7,19 l/100 km

Gasoline with hydrogen : Iн2=5,7–0,04=5,66 l/100 km

III. RESULTS

The revealed conditions of economic efficiency showed that when using composite gasoline on hydrogen fuel,

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significant economic efficiency is possible when used in urban passenger (taxi) transport.

At the same time, the amount of hydrogen added to the main fuel should be minimal-0,02 kg / h, which indicates the relevance of research on small hydrogen additives, which also corresponds to the capabilities of on-Board electrolyzers.

The operating standard of fuel consumption per 100 km of mileage is set for a passenger car with gasoline of 7,3 l / 100 km and hydrogen with gasoline of 5,7 l / 100 km. fuel economy is up to 20%. If one car travels an average of 200 km per day, the fuel economy per 100 km is 1,6 l, and per 200 km-3,2 l.

Now one liter of gasoline costs 4500 sum (0,4778 $)

(Dollar exchange rate for the Central Bank of Uzbekistan 10.02.2020, $ 1=9517.75 sum)

Then we get, saving one car:

per day 3,2*4500 = 14,400 sum (3,2*0,4778 = 1.5289 $),

for the month 30*14,400 = 432,000 sum (30*1,5289 = 45,867 $)

for the year 12*432 000 = 5 184 000 sum (12·45,867= 550, 404 $).

IV. CONCLUSION

The revealed conditions of economic efficiency showed that, in the use of composite gasoline of hydrogen fuel, significant economic efficiency is possible when used in urban passenger (taxi) transport.

At the same time, the amount of hydrogen added to the main fuel should be minimal to 0,02 kg / h, which indicates the relevance of research on small hydrogen additives, which also corresponds to the possibility of installing on-Board electrolyzers.

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