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Research Article

EXPERIMENTAL STUDY OF THE EFFECT OF ADDING HYDROGEN TO THE DIESEL ENGINE'S ECONOMIC CHARACTERISTICS

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ABSTRACT

Today, the demand for energy resources is structurally changing, especially in the transition from hydrocarbon resources to renewable sources, the development of hydrogen energy is becoming an urgent issue. In this article, the economic indicators of the D-243 engine by adding hydrogen additive as fuel are determined.

KEYWORDS

Hydrogen, power, electrolysis, experience, energy, diesel, fuel, brake, rotational speed, crankshaft, temperature, standard.

INTRODUCTION

An analysis of the development trends of the world fuel market shows a gradual transition to alternative fuels due to the depletion of traditional fuel resources and the strengthening of standards for the content of toxic substances in the exhaust gases (ChG) of internal combustion engines (IYoD). Among the alternative fuels, hydrogen is the most promising for solving the tasks of reducing waste gases and expanding the hydrogen raw material base in the future.

The conversion of the internal combustion engine to the above hydrogen fuel requires complex research and a large amount of production work due to the lack of the necessary reference. It is important to minimize engine design and

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technological changes, which require time and significant investment. At the same time, due to various reasons (technological, cost, time, etc.) in the design, limited limitations force in some cases to make non-optimal decisions that worsen the results achieved in terms of environmental and economic indicators of engines. The use of traditional methods of suppressing toxic components in hydrogen gas (exhaust gas recirculation, catalytic converters) significantly reduces the economic and power characteristics of the internal combustion engine. Thus, it is necessary to use non-standard methods to improve the environmental and economic characteristics of internal combustion engines within the established limits.

1. Diesel engine test results.

Table 1.

D-243 CHARACTERISTICS

Block material	cast iron
Fuel type	diesel
Number of cylinders	4
The number of valves in the cylinder	2
Piston path, mm	125
Cylinder diameter, mm	110
Compression ratio	16
Engine size, cubic cm	4750
Engine power, rpm/rpm	60/2200
Torque, Nm/rev.min	298/1600
Engine weight, kg	430 (D243)

Fuel consumption, l.s.	8.8
Engine-mounted vehicles	MTZ-80, 82, 892, 952 MTZ MT-353, MP-403, MGL-363, MMP-393, MPL-373 TTZ-811 TTZ-812 Belarus-90, 820, 821, 900 YeK-12, YeK-14 EO-3323 VP-05-04

1. Power and fuel economy indicators of the tractor.

In the experiments, the stands, laboratory devices and equipment of the Center for Certification and Testing of Agricultural Techniques and Technologies (QTTSM), the laboratory for testing tractor vehicles and loaders were used.

Tests were carried out on a TTZ 812 tractor rear PTO, "Rapido" weight head (made in the GDR), 160 kW electric brake stand. Experiments were carried out using an experimental laboratory device of an (electrolyzer) type hydrogen generator connected to an electric brake stand, developed by scientific staff of the Tashkent State Transport University. The methods of obtaining hydrogen by electrolysis of water are well-studied, there are industrial examples of electrolyzers with different performance, including those that meet the requirements of IYoD. Their disadvantages are a high level of energy consumption (about 3 kW of energy is needed to obtain 1 m3, that is, about 0.1 kg of hydrogen) and relatively large dimensions.

Experiments were carried out in order to determine the main power and fuel economy indicators of the TTZ-812 tractor and to use hydrogen fuel instead of diesel fuel.

The following TSTU scientific staff, doctoral students and researchers took part in the experiments:

- Ph.D., Doctor of Technical Philosophy, Ph.D., Associate Professor Ismatov J.S. ;

- TSTU basic doctoral student, research worker Ergashev O.G.

- TSTU independent researcher, Djalilav J.Kh.

By CCTAMT:

- S.A. Kunduzov, Ph.D.

- Hamzaev M.Q., head of the laboratory of CCTAMT, scientific worker;

- Toychiev E.B., the leading engineer of the CCTAMT laboratory.

Methodology:

Laboratory experiments were conducted in compliance with GOST 30747-2001 (ISO 789-1-90).

It was determined by taking into account the useful work coefficient of the intermediate reducer and the efficiency of the four-joint 2

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cardan shaft when braking through the operation of a diesel engine tractor. The rotation speed of the brake machine was recorded by the universal measuring system Testo-400. Engine fuel consumption was measured on a VNC-type scale. During the tests, the temperature of fuel and ambient air, as well as atmospheric pressure and humidity of atmospheric air were determined. During the tests, the cabin's air conditioning system was turned off. The tractor does not have a pneumatic brake system.

The following results were obtained during the experiments:

2. Power and fuel economy indicators of the tractor

Table 2.

Test results of TTZ-812 tractor through VOM

Power in VOM, kW		Rotational frequency, min-1		Fuel consumption, kg/h		Comparative fuel consumption, g/kW·h	
Diesel	When hydrogen is added	Diesel crankshaft	Tail part of VOM	Dizel	Vodorod qo‘shilgnda	Dizel	Vodorod qo‘shilgnda
Maximum power at VOM							
56,26	59,68	2200	570,78	12,21	11,28	275,9	259,4
Variation of the load on the VOM at the nominal frequency of rotation of the diesel crankshaft							
56,87	59,26	2205	572,15	12,04	11,18	280,59	244,78
56,49	59,95	2104	571,69	11,93	11,08	275,69	250,89
56,76	59,18	2022	571,23	11,52	11,02	271,06	259,28
56,26	59,68	1918	570,78	10,95	10,12	275,9	259,4
56,23	59,63	1808	570,32	10,55	10,05	270,38	258,43
Variation of VOM tail rotation frequency at full load							
56,44	58,9	1705	546,12	10,22	9,39	267,36	243,89
47,29	49,09	1582	410,5	9,48	9,14	260,36	247,89

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47,02	49,93	1528	396,35	9,46	9,04	250,98	259,94
Average							
54,4	57,25	1896	501.10	98,36/9=10,92	92,4/9=10,26	269,8	253,76
The average difference has increased by 5%				The average difference is a 6% reduction in fuel consumption		The average difference is a 6% reduction in fuel consumption	

The maximum rotation frequency of the diesel crankshaft at idle, min-1 2293.

Torque in VOM at the tail part rotation frequency corresponding to the nominal rotation frequency of the diesel crankshaft, N·m 864.62

Torque in VOM when the diesel engine is operating in the maximum torque mode, N·m 1025.75

Rotational frequency of the VOM tail section when the diesel engine is operating in the maximum torque mode, min-1 410.5

Atmospheric conditions (average values during the test):

- ambient air temperature oS + 9.5
- atmospheric pressure kPa 99.1
- relative humidity of ambient air % 59.9

Maximum coolant temperature oS 80.

Engine oil temperature, oS 80.

Table 3.

Power and fuel economy indicators of the tractor brought to standard atmospheric conditions

indicators	Meaning of indicators		
	According to the factory	To test data than in diesel	When hydrogen is added
1	2	3	4
1 tractor performance indicators in VOM:			

- maximum power in VOM at the regulated rotation frequency of the engine crankshaft (2200 min-1), kW (h·p)	Not less than 54	54,4	57,25
- the relative fuel consumption at the nominal rotation frequency is 2200 min-1 g/kW·h	Not more than 255	269,8	253,76
2 Engine performance indicators:			
- Maximum engine power kW (h·p) in the package and in the conditions of the corresponding operating power	59	59,43	62,54
- rotation frequency of the engine crankshaft at maximum power, min-1	2200	2200	2200
- relative fuel consumption g/kW·h at maximum power	269	269,8	253,76

Analysis of power and fuel economy indicators according to the results of tractor PTO brake tests

In order to determine the main power and fuel economy indicators and to evaluate their compliance with the factory data, brake tests were carried out using the VOM of the TTZ 811 tractor with a diesel engine of the D-243 model.

The tests of braking the tractor through the rear PTO were carried out on the electric brake stand with a power of 160 kW, with a "RAPIDO" weight head (manufactured by GDR) and a step-up reducer with a gear ratio of ip=2.19.

The parameters of the tractor with a diesel engine were determined in accordance with GOST 30747-2001 (ISO 789-1-90) when braking through the VOM using an intermediate reduction gear and 2 cardan shafts with four articulated joints, the frequency of rotation of the brake machine by electropulse collection of revolutions recorded by the counter.

Engine fuel consumption was measured on VNTs type scales. During the tests, the temperature of fuel and ambient air, as well as atmospheric pressure and humidity of ambient air were determined.

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The VOM indicators of the tractor obtained during the tests were brought to standard conditions, and the values of the correction coefficients are used from GOST 18509.

Fig. 1. Research of "Rapido" electric brake stand

The coefficient of useful work in transferring the torque from the engine to the output shaft of the power take-off device was assumed to be equal to 0.92.

According to the results of brake tests of the tractor during 39 hours of operation, the maximum power in VOM is 54.4 kW at a crankshaft rotation frequency of 2200 min-1, 57.25 kW with the addition of hydrogen (according to factory data - more than 54 kW was not 'p').

At maximum power, the specific fuel consumption was 253.76 g/kW·h with hydrogen addition of 269.8 g/kW·h in diesel (according to test data, 269.8 g/kW·h does not exceed).

The coefficient of nominal torque reserve was 18.63%, which is within the permissible requirements (15%).

CONCLUSION

The maximum power of the TTZ 811 tractor with the D-243 engine at VOM is 5-13% more than the factory requirements, which can be explained by the sufficient performance of the tractor.

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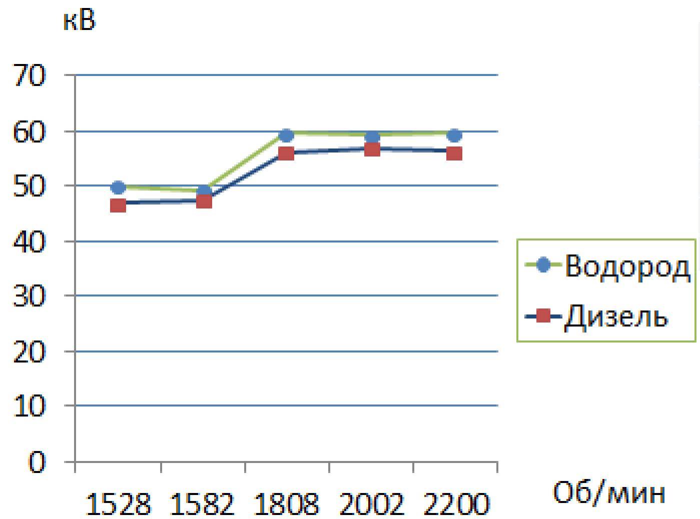
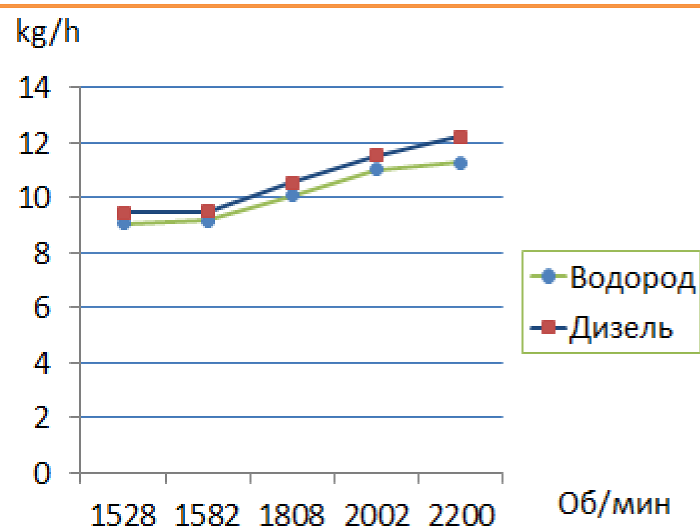


об/мин	Водород қўшилганда	Дизель
1528	49,09	47,02
1582	49,09	47,29
1808	59,63	56,23
2002	58,18	56,76
2200	59,68	56,26

Ўртача фарқ 5,73 %

Figure 2. The difference between power (kW) in VOM when hydrogen is added and in diesel.

The analysis of the results showed that, under the adopted conditions, the addition of hydrogen in the studied operating modes of the engine has practically no significant effect on the FIK of the engine.



об/мин	Водород қўшилганда	Дизель
1528	9,04	9,46
1582	9,14	9,48
1808	10,05	10,55
2002	11,02	11,52
2200	11,28	12,21

Ўртача фарқи 6 %

3 - picture. Efficient fuel consumption.

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This conclusion. This is clearly confirmed by the results presented in Figure 3, which shows the variation of the engine's effective FIKi in different modes of operation. It should be noted that the effective FIK of the engine at n = 1600 min-1 varies significantly due to uncertainties in the measurement of fuel consumption.

The exception is the SY mode, where the amount of heat supplied to the engine increases significantly with the addition of hydrogen. (See Figure 3).

This is due to the fact that with an increase in the amount of hydrogen, it is not possible to further reduce the cyclic fuel supply of the engine.

Compared to diesel, the specific fuel consumption is reduced by 6% from the test requirements.

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