

Conference Paper

Justification for the Conversion of a Combine Harvester to Operate on Compressed Natural Gas

Andrey Ivanov

Northern Trans Ural State Agricultural University, Tyumen, Russia

Abstract

The article considers the issue of expanding the use of gas motor fuel in the agricultural sector on agricultural machinery. Several regulatory documents on the regulation of relations in the use of gas motor fuels and on energy conservation and energy efficiency in agriculture are indicated. It was noted that the conversion of agricultural machinery, in particular, combine harvesters to compressed natural gas, has been little studied and little attention has been paid to this, although this area is promising, especially for the Tyumen region of Russia, since it has huge reserves of natural gas. The use of natural gas as a motor fuel on a combine harvester is more expedient than the use of liquid fuels, since such gas is a more economical, safe, environmentally friendly and environmentally friendly type of fuel. An Acros-530 combine harvester was chosen as the object of study. The purpose of the study is to increase the efficiency of the combine by converting it to work on gas fuel. The technical characteristics of the gas engine Yaroslavl Engine Plant-53644 CNG, which is proposed to be used instead of a regular diesel engine, are considered. Analysis of the design of the Acros-530 combine allowed us to determine the place for placing gas cylinders, as well as the mounting points of the developed frame designs on which gas cylinders will be mounted. It is planned to install 9 cylinders with a capacity of 276.9 cubic meters on the combine. m compressed natural gas. An analysis of the technological operations of grain harvesting using a gas processor showed the possibility of achieving an annual economic effect for a field of 1,500 hectares of more than 100,000 rubles, mainly due to a reduction in fuel costs by 3.5–4.5 times.

Keywords: gas, fuel, methane, combine, frame.

Corresponding Author:

Andrey Ivanov

Received: 25 October 2019

Accepted: 15 November 2019

Published: 25 November 2019

Publishing services provided by
Knowledge E

© Andrey Ivanov. This article is distributed under the terms of the [Creative Commons Attribution License](#), which permits unrestricted use and redistribution provided that the original author and source are credited.

Selection and Peer-review under the responsibility of the AgroSMART 2019 Conference Committee.

1. Introduction

It is difficult to imagine the active development of the fuel and energy complex of Russia without increasing the use of gas motor fuel in various sectors of the economy, including the agro-industrial complex using agricultural machinery.

There are several regulatory documents both at the level of the Government of the Russian Federation and the Government of the Tyumen Region, on regulating



relations in the use of gas motor fuels and on energy conservation and increasing energy efficiency in agriculture [1, 2].

The conversion of agricultural machinery, in particular, combine harvesters to compressed natural gas (CNG), has been little studied and not enough attention has been paid to this, although this area is promising, especially for the Tyumen region, as it has fairly large reserves of natural gas (Figure 1) [3]. As for the stocks of other types of fuels, their quantity is much smaller.

It should also be noted that the use of CNG as a motor fuel on a combine harvester is more expedient than the use of diesel fuel, since it is such a gas that is a safer, more economical, and environmentally friendly type of fuel [4, 5].

The cost of natural gas is 3--3.5 times less than the cost of diesel fuel. Moreover, regarding fuel consumption, 1 cubic meter. m. CNG is equivalent to 1 liter of diesel fuel. In addition, gas-cylinder equipment pays off faster than diesel-powered vehicles, despite a higher acquisition cost. To ensure a minimum content of toxic substances in the exhaust gases of gas-filled vehicles, expensive catalytic systems are not required, which means additional savings on operating costs.

Natural gas is one of the safest fuels used. Methane in an amount of up to 98% of the total mass is the main component of natural gas [6]. Methane is almost 2 times lighter than air, therefore, in case of depressurization of equipment, it immediately disappears, and does not settle, unlike other types of fuel. Methane is not toxic and carcinogenic, it is safe for human health and the environment, so the use of such fuel in combines that directly interact with plant materials is very important.

2. Methods

An Acros-530 combine harvester was selected as the object of study (Figure 2). This combine and its modifications are widely used on the fields of the Tyumen region and Russia, it has high economic efficiency and the availability of operational service support in the region. Currently, more than 10,000 such combines are operating.

The purpose of the study is to increase the efficiency of the combine by converting it to work on gas fuel.

2.1. Research objectives

1) to analyze the design of the combine for the installation of gas equipment;



Figure 1: Natural gas reserves in Russia.

- 2) to develop frames for attaching gas cylinders;
- 3) evaluate the efficiency of the gas fuel harvester.





Figure 2: Combine harvester Acros-530.

The conversion of the Acros-530 combine to CNG requires the installation of gas equipment, as well as, in our case, the replacement of the existing YaMZ-236 diesel engine with a gas engine. As a gas engine, you can use the YaMZ-53644 CNG engine, manufactured by the Yaroslavl Motor Plant and designed to operate on CNG. Comparative characteristics of the engines are presented in table 1.

The process of re-equipment of the combine also includes the need to install the following components: a gas cylinder, which is equipped with parts allowing safe

operation to fill it, power the engine, and determine the level of gas contained in it (Figure 3); a gas pipeline conducting gas from a gas cylinder to an engine; a pressure reducer used to convert methane from high loading pressure to use pressure.

TABLE 1: Technical characteristics of engines.

Name of indicator	YEP-236	YEP-53644 CNG
		
Number and arrangement of cylinders	V6	R6
Cylinder diameter, mm	130	105
Piston stroke, mm	140	128
Cylinder displacement, l	11,15	6,65
Power, kW (h.p.)	184 (250)	190 (258)
Rotation frequency, min ⁻¹	2000	2300
Maximum torque, Nm	1030	1098
Speed at maximum torque, min ⁻¹	1100 -- 1300	1100 -- 1600
Specific effective fuel consumption, g / kW · h (Nm ³ /kW · h)	215	0,134
Dimensions, m	1,21x1,045x1,1	1,128x0,815x1,2
Weight, kg	985	603
Harmful emissions	Euro I	Euro V

3. Results

Analysis of the design of the Acros-530 combine allowed us to determine the location for the placement of gas cylinders (Figure 4), as well as the attachment points of the developed frame designs on which the gas cylinders will be mounted (Figure 5). It is planned to install 9 cylinders with a capacity of 276.9 cubic meters on the combine. m CNG with a working pressure of 20 MPa.



Figure 3: Super lightweight composite CNG cylinders.

The designs of the designed frames 1 and 2 are shown in Figure 6 and 7. Frame 1 is designed to accommodate 6 cylinders, and frame 2 for 3 cylinders.

The cost of fuels and lubricants (in the conditions of Russia) per 1 ha of cultivated area with a standard consumption of 33.7 kg / ha of diesel fuel and 24.8 m³/ha of gas fuel is presented in Figure 8.

An agricultural enterprise with a small sown area was chosen as the base farm for the study. Calculation of technological operations direct combining showed that for a wheat field with an area of 900 hectares and a yield of 42 kg/ha, the reduction in total costs for the entire operation will amount to 266,000 rubles; an oat field with an area of 600 ha and a yield of 44 kg/ha will reduce costs by 169,000 rubles (Table 2, Figure 9).

The farm under study, by the standards of agricultural production, has relatively small sown areas, is a small farm, however, the total savings when harvesting a farm with only one Acros-530 combine will amount to 208400 rubles.

An analysis of the technological operations of harvesting crops using a gas harvester showed that despite significant investments in the conversion of a combine harvester, it is possible to achieve an annual economic effect for a field of 1,500 ha over 100,000 rubles, mainly due to a reduction in fuel costs of 3.5–4,5 times.

TABLE 2: The results of the calculation of technological operations.

Culture	Area, ha	Productivity, dt / ha	Cost reduction, %	Cost reduction, rub.
Wheat	900	42	34	590000
Oats	600	44	31	367000
Total:	1600	--	--	957000

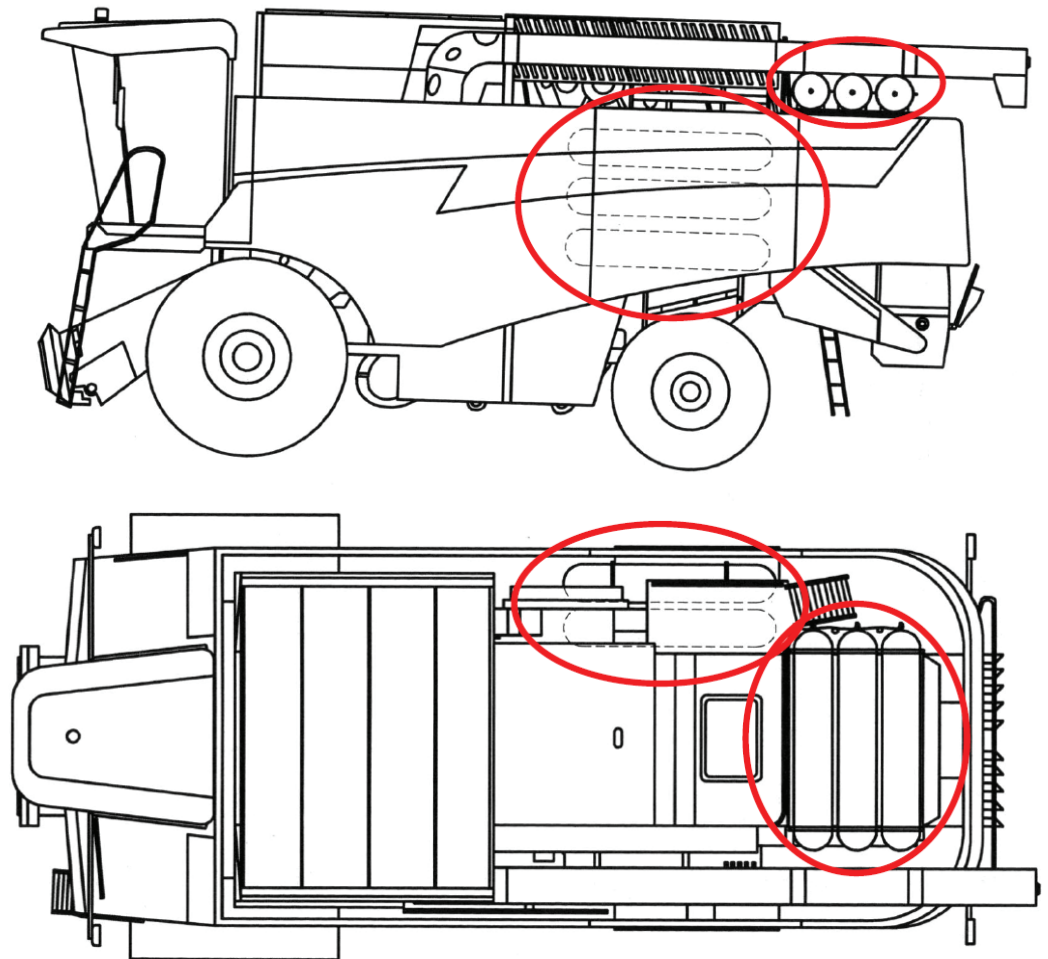


Figure 4: The layout of the gas cylinders on the combine.



Figure 5: Mounting points of frame 1 (a) and frame 2 (b) for gas cylinders.

4. Conclusion

It is not enough to convert the combine to gas fuel, it is necessary to provide it with gas infrastructure, that is, gas fueling points. And with this, there are a few problems regarding CNG refueling. In the south, the only automobile gas-filling compressor station

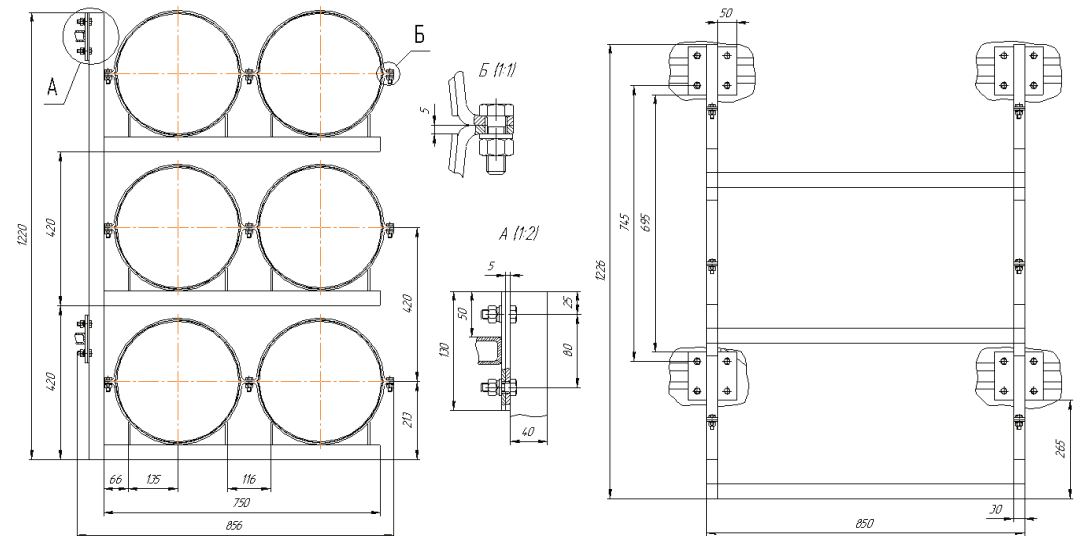


Figure 6: Frame design 1.

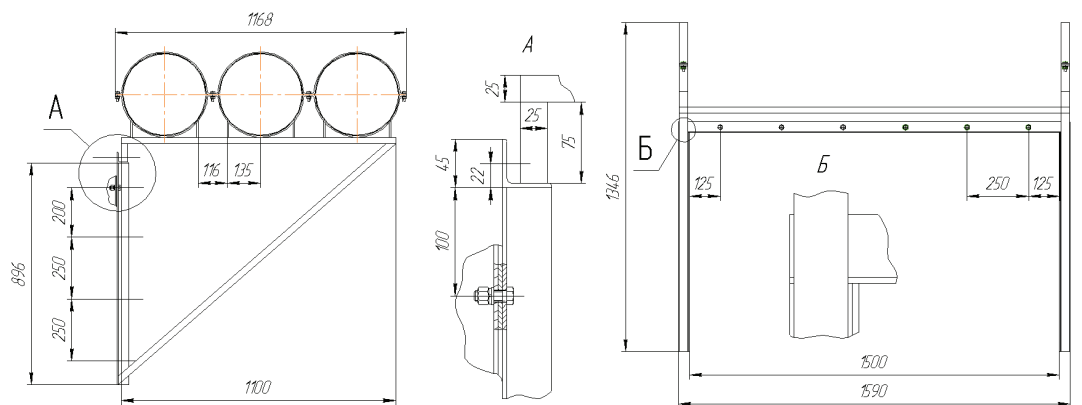


Figure 7: Frame design 2.

operates, which refuel CNG, which is a very significant constraint to the conversion of agricultural machinery to methane.

However, along with the construction of gas stations, it is necessary to solve several basic measures to ensure the effective gasification of agricultural machinery:

1. Development of incentive methods for enterprises using natural gas as a motor fuel, including tax and other benefits at the regional level;
2. Inclusion of gas-filling equipment in the state register of agricultural machinery and equipment for sale to agricultural producers on a finance lease;
3. Inclusion of equipment for the use of natural gas as motor fuel in the list of equipment, the acquisition of which is subsidized from the regional budget;
4. Justification and efficient use of the fleet of multifunctional mobile gas filling complexes, considering the needs of agricultural enterprises;

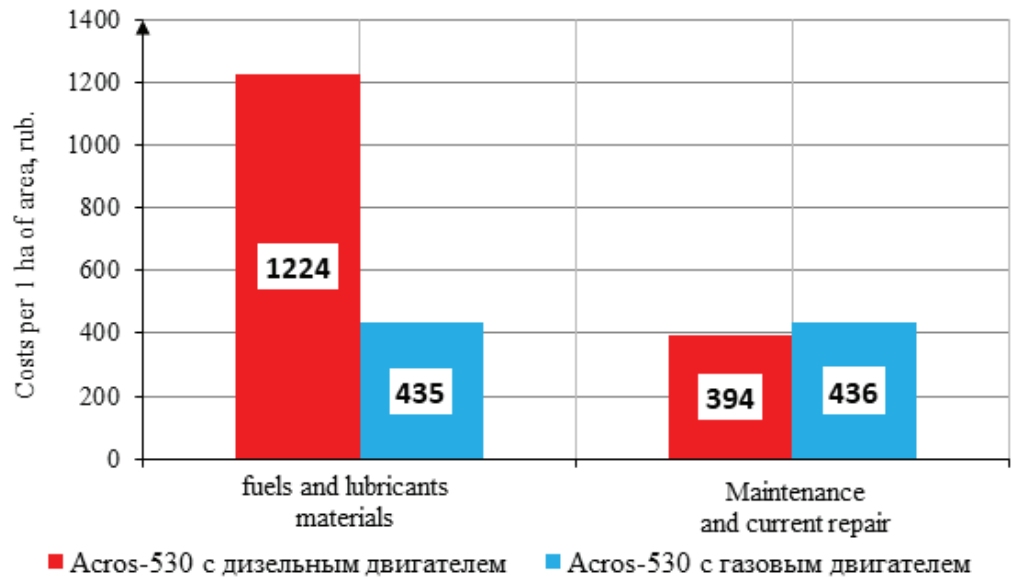


Figure 8: Costs per 1 ha of cultivated area.

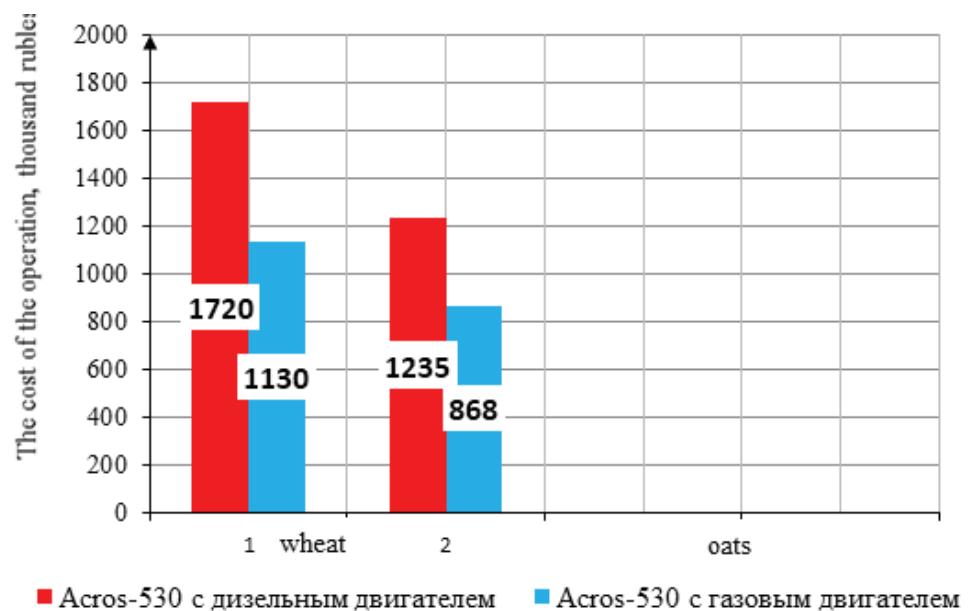


Figure 9: The total cost of technological operations.

5. Implementation of small-sized gas-filling compressor units and block-modular gas-filling stations of the garage type for agricultural enterprises.

Conflict of Interest

The author has no conflict of interest to declare.

References

- [1] Order of the Government of the Russian Federation of 13.05.2013 N 767-r "On the regulation of relations in the use of gas motor fuel".
- [2] On approval of the state program of the Tyumen Region "Energy Saving and Improving Energy Efficiency" until 2020. Decree of the Government of the Tyumen Region dated December 22, 2014 N 662-p (as amended by the Decree of the Government of the Tyumen Region dated 30.12.2015 N 671 p) Subprogram N 5 "Energy conservation and energy efficiency in agriculture".
- [3] Chikishev, E., Ivanov, A., Anisimov, I., Chainikov, D. Prospects of and Problems in Using Natural Gas for Motor Transport in RUSSIA. *IOP Conference Series: Materials Science and Engineering*, vol. 142, no. 1.
- [4] Bielaczyc, P., Szczotka, A., Woodburn, J. A comparison of exhaust emissions from vehicles fuelled with petrol, LPG and CNG. *IOP Conference Series: Materials Science and Engineering*, vol. 148, no. 1.
- [5] Nix, A.C., Sandoval, J.A., Wayne, W.S., Clark, N.N., McKain, D.L. Fuel Economy And Emissions Analysis Of Conventional Diesel, Diesel-electric Hybrid, Biodiesel And Natural Gas Powered Transit Buses. *WIT Transactions on Ecology and the Environment*, vol. 150, pp. 895–908.
- [6] Anisimov, I., Ivanov, A., Chikishev, E., Chainikov, D., Reznik, L., Gavaev, A. (2017). Assessment of adaptability of natural gas vehicles by the constructive analogy method. *International journal of sustainable development and planning*, vol. 12, iss. 6, pp. 1006–1017.