

Justification of the type of combine harvester for farms

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Abstract. We presented results of the tests of combine harvesters of domestic and foreign manufacturers over the past ten years. We presented recommendation about the choice of the studied technology.

1 Introduction

The modern industrial market of the Russian Federation is extremely wide and varied in the choice of a self-propelled combine harvester for harvesting cereal and other crops. It is enough to say that there are 598 combine harvesters of imports production from 2691 ones in the Kursk region, It is 22.2%, which means that in other regions this figure may approach 50% or even be more than this value . This fact is connected with each manager's principles during choosing a combine. Someone focuses on the famous names of manufacturers ("CLAAS", "JOHN DEERE", "NEW HOLLAND"). Someone attracts to the most up-to-date and foreign fashion technologies, and to someone's seems that the impressive cost and record (super) productivity will guarantee successful work. Such farms are still exist, but there are other farms for which, first aim is financial result, who are looking for and finding the optimal solution in everything, including the choice of agricultural equipment, which plays an important role. These are those for whom grain production is a profitable business, and not a "battle" for the harvest at any cost [1,6].

The aim of the research is justification of the necessity to using the main group of combine harvesters for agricultural commodity producers in the Russian Federation.

2 Materials and methods

The studies were carried out according to the results of tests at the Central Chernozem State Zonal Machine Testing Station.

3 Results and discussions

In Russia, the leading manufacturer of combine harvesters is combined plant «Rostselmash», which annually produces about 5,000 combine harvesters. It should be

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noted that even in 2006, the Central Chernozem Machine Testing Station has been conducted tests of an experimental-industrial batch of combines harvesters ACROS-530 and the first ACROS, which left the main conveyor and worked on the fields of the enterprise Agroholding «Rysagro», Zherdeevsky district of the Tambov region.

We will not particularly focus on the combines series RSM-142 (“ACROS-530”, “ACROS-560” and “ACROS-580”); by the way, the more productive “ACROS-550” replaced the “ACROS-530”, state tests were held in 2014) and RSM-152 (“ACROS-590” and “ACROS-590 Plus”) of the 5th class, the threshing unit of which is represented by the classical scheme of the threshing-separating device (TSD) and in the following version: threshing cylinder with a diameter of 800 mm and a bumper beater with a diameter of 300 mm. The productivity of these combines ranges from 16 to 20 tons per hour of main time. These batch with equal values (1500 mm) of the threshing part only slightly differ by the cleaning area and power of the installed engine.

In the harvest season of 2014 year, the ACROS-550 combine was tested, the design of which mainly consisted of six changes compared to the ACROS-530: instead of the YaMZ-236BK-4 engine with power 187 kW (255 h.p.) , the YaMZ-236BE2-36 engine with a power of 206 kW (280 hp) was used. This change was caused in order to improve its consumer properties. Characteristics of harvested winter wheat satisfied the regulatory requirements excepted the ratio of grain mass to straw mass of over the actual cutting height of 1:1,1, and the field (moisture and soil hardness in the layer from 0 to 10 cm)/

In these operation conditions, which practically satisfied the requirements, “ACROS-550” in the unit with a header of 7 m in constructional width of the construction of the technological process with the loss of grain at the threshing equal to 1.45% , 5%) and behind the header - 0.17% with permissible no more than 0.5% and the qualitative composition of the bunker pile: the content of weed impurity is 0.17% and the grain size is 1.8% (standard values, respectively: no more than 2 %) on the direct combining of winter wheat while working second speed 6.4 km / h provided the productivity per hour of normal time equal to 17.11 t/h, which is 7% higher than the value for «ACROS-530”. Specific fuel consumption during the shift work amounted to 7.66 kg / ha (1.94 kg / t).

It is very interesting to study combine harvester of the 6th class - the RSM-161. It has classic threshing unit scheme, but with 4 drum scheme and with installed Cummins engine with power 272 kW (370 hp) and embodied advanced research in foreign combines. Threshing unit of this combine includes threshing drum with width 1630 mm (1500 mm - RSM-142 and RSM-152) and diameter 800 mm, concave of the threshing drum transporting a blade beater with diameter 400 mm with concave, a rotary separator drum with a diameter of 740 mm with concave diameter 320 mm - bladed rear beater, 6-key straw rack, two-stage cleaning system with a dynamic alignment of the upper sieve on the slope, due to which the sieve moves in three dimensions: back and forth, up and down and left-right, the lower sieve preliminary sieve, shaker pan, centrifugal radial fan with double-sided multiple-air intake regulation and electro transporting device, grain bunker with a capacity of 10.5 m³ unloading auger tower type.

From 2013 to 2016 we have conducted tests of the combine harvester RSM-161 in a set with all adapters: a grain header RSM -161.27 (9 m) on a direct combination of winter wheat (2015) and a mid-season soybean variety (2016); device for harvesting rapeseed PRBZH-P9MR (2016), which were mounted on the above-mentioned grain header; a device for harvesting corn PPK-121 "ARGUS" (2014) and a device for harvesting sunflower PSP-1210 "FALCON" (2015).

Table 1 presented the test conditions, mode of operation, operational, technological and functional indicators in the RSM-161 in the configuration on these adapters.

Weather conditions did not prevent the harvesting of rapeseed and soybean crops. However, quite often precipitations (rain) significantly increased soil moisture in a layer of

0 ... 10 cm, which on rape was 24.8%, and soybeans - 30.0%, which is significantly higher than the permissible value for technical conditions (TC) for self-propelled combine harvesters - up to 20%. The moisture of the nongrain part of rapeseed plants for the period of determination of operation-technological parameters was 18.8%, which is more than the value of multi-year data (10 ... 14%). Its increase was influenced by the not quite high-quality conduct of desiccation (centering) of rape, as during the period of its harvesting the individual stems had a higher humidity (greenish color). Quite frequent precipitation during the period of soybean harvesting could not but affect the moisture content of the seeds of this crop and the non-grain part, which (moisture) was respectively 21.0 and 53.0%, which also did not conducted TC of the soybean header universal life support: from 12 to 15% and from 10 to 20% respectively. It should be noted that the sowing of soybeans was made for 10-14 days late of the planned agrotechnical period, and the chemical treatment (desiccation) used for accelerated ripening and drying of plants at the root did not produce the expected effect, since the maturation of soybeans took place in cool weather those. Its processing was carried out in violation of the temperature regime. All this ultimately affected the harvesting of these crops, namely, the working speed of the cleaning unit, and, consequently, the productivity and specific fuel consumption.

In 2015, ideal conditions were created for harvesting cereal crops, both for combines with the classical scheme of threshing and separation of grain, and with rotary threshing unit. According to such important indicators of the test conditions for all combine harvesters, regardless of the type of threshing-separating device, are as the ratio of the mass of grain to the mass of straw over the actual cutting height (1: 0.6), the absence of contamination of crops and their incidence. - the units of the standard value (not more than 20%), the height of wheat plants equal to 75 cm, made it possible in these conditions of operation when carrying out laboratory-field tests of the combine harvester RSM-161 to get the nominal performance at the level losses at its threshing machine 1.5% equal to 29.25 t / h.

With an installation cut height of 16 cm, as a the total grain losses behind the combine harvester on 3-speed modes of movement of the harvesting unit (6.7; 7.3 and 9.3 km / h), and the grain losses behind the header with the structural 9 m wide at 2-speed modes (7.3 and 9.3 km / h) were obtained within the regulatory requirements. The crushing of grain by the transporting bodies of the combine ranged from 1.91 to 1.98%, which met the Normative conditions — no more than 2%.

The bunker heap on all modes was obtained clean - the content of weed impurities, namely organic, was only 0.05 ... 0.08%, which naturally satisfied the permissible value - no more than 2%. Test RSM-161 in the configuration with the appropriate adapters once again confirmed its stated characteristics. Combine RSM-161 embodied the most advanced and promising, which is used on foreign combines (automatic copying of the soil relief, electromechanical method of changing the opening value of louvre sieves, a single hydraulic connector for connecting with adapters, comfortable conditions for the operator, etc.).

Table 1. Results of tests of combine harvester RSM-161

Indicator	Value of the indicator					
	Standarts - wheat	данные испытаний культурам				
		wheat	rapese ed	soy	corn	sunflow er
1	2	3	4	5	6	7
<i>Test conditions</i>						
Grain yield, t / ha	Not less 40	35,9	13,0	30,0	79,4	20,8
The ratio of the grain mass to the straw mass over the actual height of the cut	1:1,5	1:0,6	1:2,8	1:3, 3	-	-
1000 grains weight, g	Not less 40	34,2	3,1	198	-	-
Humidity,%:						
- grains (seeds)	от 10 до 25	13,8	10,3	21,0	25,3	10,3
- straw	от 10 до 35	12,5	18,8	53,0	-	-
- leaf stalk mass	-	-	-	-	21,5	43,7
- baskets	-	-	-	-	-	50,4
Plant height, cm	No date	79	101	125	-	-
Plant flexibility,%	no more 20	11,6	15,4	10,0	-	-
Weed of crop,%	no more 1	0	2,2	0,2	-	-
Soil moisture in the layer of 10 cm,%	Before 20	15,9	24,8	30,0	14,0	18,6
Soil hardness in a layer of 10 cm, MPa	No date	1,1	1,1	1,2	1,2	1,0
<i>Operation mode</i>						
The speed of the unit, km / h	no more 12	7,3	7,0	5,2	5,1	6,2
Working width of the header, m	No date	8,8	8,8	8,75	8,40	8,40
Actual cutting height, mm	same	15	22	10	17	97
<i>Operational and technological indicators</i>						
Productivity, t / h:						
- main time		25,10	8,50	12,7	34,10	9,91
- changeable time	Not less 20	16,60	5,78	8,40	22,50	6,44
- operational time	No date same	15,60	5,44	7,89	22,50	6,44
Specific fuel consumption during shift work, kg / t	No date	2,24	6,80	4,00	1,82	6,52
Operational and technological factors:						
- process reliability	No date	1	1	0,96	1	1
- use of changeable time	same	0,66	0,68	0,66	0,66	0,65
- use of operating time	-	0,62	0,64	0,62	0,66	0,65
<i>Functional indicators</i>						
Total grain losses per bit,% including:						
- grain loss at the threshing drum	no more 2	1,16	0,95	1,74	1,40	-
- loss of grain for the header	no more 1,5 no more 0,5	1,06 0,10	0,53 0,42	0,74 1,00	0,60 0,80	- 0,87
Grain quality from a combine bunker,%:						
- grain crushing	no more: 2	1,94	1,70	1,01	3,8	0,61
- content of weed impurity	2	0,06	1,00	0,99	1,30	2,62

All these innovations have been applied in the design of the batch of rotary combine harvesters TORUM. It is also produced by the Combine Plant Rostselmash.

The 7th class is represented by this manufacturer not by the classical Threshing Drum scheme, but by the rotor one. This is a batch of RSM-181, including, "TORUM-740" with engine YAMZ-7511.10-40, power 294 kW (400 hp); "TORUM-760" with the engine

"Cummins" QSX11.9 power of 365 kW (496.3 hp); "TORUM-780" - Mercedes Benz OM 460LA. E3A8-00 with a power of 375 kW (510 hp) and "TORUM-790" - OSZ-13372 with a power of 368 kW (500 hp).

From this batch of combines, in 2014, the Central-chernozem Machine test station conducted type tests "TORUM-780" in a unit with a 9-meter header. During the harvest season of that year, there were ideal conditions for the operating combines harvester with rotary Threshing Unit: the yield of winter wheat varied in the range of 405 ... 426 kg / ha with the ratio of the grain mass to the straw mass over the actual cut height 1 : 1,1; 1000 grains mass was equal to 40.3 g, and debris - only 0.3% with a pit of 1.0% and a plant height of 83 cm, but the most important thing is grain moisture 14.2% and straw - 14.0% (according to Normative - The value for both of these indicators - from 10 to 18%). The moisture content and hardness of the soil in the layer from 0 to 10 cm were 18.2% and 1.2 MPa, which also satisfied the Normative value, respectively: up to 20% and not less than 1.0 MPa.

The productivity for 1 hour of the main time in the such operating conditions and with the steady performance of the process with operating speed 7.5 km / h , working width of the header 8.8 m was obtained equal to 27.0 t / h (according to Normative - not less than 24 t / h), it is confirmed by the efficiency of replacing the engine YMZ-7511.10-40 with a capacity of 294 kW (400 hp) in "TORUM-740" to a Mercedes Benz engine with a power of 375 kW (510 hp) in "TORUM-780". The operation quality indicators are also obtained at the level of requirements (losses: after threshing drum — 1.41%, after the header — 0.14%; content trash in the bunker heap — 0.32%, and crushing — 1.01%) . The specific fuel consumption during changeable time was obtained equal to 7.95 kg / ha (1.93 kg / t).

Tests have shown that the combine TORUM-780 doesn't concedes in all indicators of the quality of the implementation of the technological process to its analogue John Deere S 660 combine (rotor length is 3124 mm, diameter is 762 mm, total cleaning area is 5.4 m² and separation is 3.0 m²), which tests were conducted (2012) in comparison with the KZS-1218 and in performance (due to the installed greater engine power) exceeds it.

The second important manufactories of combines is combine plant "Bryanskselmash" (more than 1000 units per year), which produces the following combines: KZS-1218 (5 - class with a productivity at least 18 t/h); KZS-10K (5-class with a productivity at least 14 t/h); KZS-812 (5 -class with a productivity up to 12 t/h). In the design of the combines harvesters KZS-10K and KZS-812, unlike the KZS-1218, the drum-accelerator is already absent. These combines have equal diameters of threshing drum (800 mm) and tine breaker (400 mm), but they are differ in the such main indicators: engine power YaMZ-236BE2-28 184 kW (250 hp) against, respectively, D-260.4-526 152 kW (210 hp); threshing width 1500 to 1200 mm; cleaning area 5.0 vs. 3.85 m²; the number of straw walker keys (5 and 4) and naturally differ in fuel tank capacity (500 and 300 liters) and bunker capacity (7.0 and 5.5 m³).

Analysis of the test results showed that it conformed the regulatory requirements in terms of the quality of the performance of the technological process and the indicators of the destination.

The Gomselmash Scientific and Technical Center for Combine Design of the Republic of Belarus produces the following high-performance combine harvesters: GS14 (feed 14 kg / s) with the usual classical Threshing Unit Scheme and 6 keyboard straw shaker with a width of 1700 mm thresher and cleaning area 5,8 m²; GS16 (feed 16 kg / s) also with the usual classical Threshing Unit Scheme, but already with two straw separator rotors with a thresher width also 1700 mm and a length of each rotor 4260 mm, diameter 445 mm and a cleaning area of 5.8 m². Imported engines (respectively Cummins 294 kW (400 hp) and Mercedes Benz 390 kW (530 hp)) are installed on these combine harvesters. For small farms, this company offers a self-propelled combine harvesters - KZS-5, which successfully passed acceptance tests on the fields of the Central-Chernozem Machine Test Station in

2014. Enterprise “Lidagrommash” (Republic of Belarus) produces two types of combines harvesters: Lida-1300 (4-class - a three-drum cleaning and separation system: a threshing drum with a diameter of 600 mm, a fender beater with a diameter of 400 mm and a separation drum with a diameter of 570 mm; separation area of 4.6 m² and cleaning 6.5 m²) and Lida-1600 – 5-class. The production of the Lida-1600 (high-performance combine harvester (at least 18 t / h)) is still very small: from 2009 to the present it is produced only more than 450 combines. The tests of the combines Lida-1300 and Lida-1600 confirmed their stated characteristics, and such an indicator as the content of trash in the bunker heap of the combine was obtained less than other similar combines. Analysis of the combines park in the farms of the Kursk region showed that a significant proportion of its structure ACROS-580 and KZS-1218, equivalent in 5-class productivity. The results of the combine monitoring carried out by order of the Ministry of Agriculture of the Russian Federation for four years (2013–2016) in ordinary operation show that they provide the performance specified by the Normative and the quality of the technological process, and their technical reliability is sufficient level. From all foreign firms, only one company CLAAS offered to assess the quality of indicators of the appointment of the Mega-204 combine on four crops (wheat, buckwheat, corn and sunflower), when it had appeared in domestic market. In the design of this combine, as in the other combines of this company (“Mega-360” and “TUCANO” series), the usual classical LSG scheme (as well as in KZS-1218) is applied: a blade drum-accelerator, threshing drum and an air fender (reversible drum) beater. The tests carried out on direct combining of winter wheat and in comparison with our domestic combine “Don-1500B” (2002) showed even then that, in terms of the quality of work, our domestic combines are in no way inferior to foreign analogues, and for even more convincing Answer to the question: (domestic or foreign combine), in our opinion, it is enough to refer to the results of the 2009 harvest. According to official data, in the harvest season of the cereal crops of that year about 100 thousand on average are not new combines (as part of the park “Nivushka” - this is how affectionately mechanics called the combine SK-5 “Niva” and “Dona” of various modifications and possibly about 10% of new and foreign combines) harvested 90 million tons of grain.

4 Conclusions

It should be noted that there is no consensus among specialists on the prospects for the development of rotary harvesters, but most of them agree that combines with axial-rotary thresher scheme will mainly be used in areas where corn is harvested grain and ripen dry short stalk varieties of wheat and other crops.

It must be admitted that for some reason, foreign companies do not offer to evaluate the quality of the work of their manufactured harvesters in the conditions of harvesting our country, although they supply them in significant quantities and at a significantly high purchase price.

Carried out on the instructions of the Ministry of Industry and Trade of the Russian Federation by the five leading machine-testing stations in 2012, including the Central-chernozem Machine test station, comparative tests of entire groups of combines proved once again that foreign combine harvesters are financially promising, and our domestic combines in terms of the quality of the technological process, performance and fuel consumption are not inferior to foreign counterparts.

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