*Jr. of Industrial Pollution Control 33(2)(2017) pp 1163-1170*
*www.icontrolpollution.com*
*Research Article*

# DISTRIBUTION OF MASSES AND TECHNOLOGICAL SCHEMES OF AGRICULTURAL COMBINES

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(Received 17 July, 2017; accepted 19 July, 2017)

**Key words:** Distribution of masses, Harvest unit, Technogenic influence, Technological system, Structure, Synthesis

**ABSTRACT**

The problem of quality of running systems impact of high-performance combine harvesters on productional layers in agroecosystems is considered in the article. The directions of removal or decrease of this influence on the ways of design redistribution and technological mass of grain-harvesting units are defined. It is offered to carry out processing of a design of high-performance combine harvesters so that to lower unit loads on running devices. Four main design flow diagrams of grain-harvesting units which parts mobile power means of agricultural appointment of the fifth generation are synthesized. All four schemes presented in article are carried out by redistribution of mass of grain-harvesting units on padding running devices that considerably reduces specific pressure on the soil. At the same time motor installation for other use is released in non-harvest time.

## INTRODUCTION

It is possible to claim that development of grain hardware production in agro-industrial complex of the countries with intensive agriculture including in Russia, was always directed to increase in efficiency of working processes. At an invariable design flow diagram of the main harvester – the combine harvester – the problem is solved directly: due to increase in the working masses. So, in 1956 in Russia the mass self-propelled SK-3 combine harvester was put on production; at a channel capacity of that car in 2.6 kg/s he got a gold medal at the World Bruxelles Fair as "single and the best in the world". Now, in 50 years Russia, in particular, has the self-propelled combine harvester a channel capacity of 8 kg/s, i.e., three times more productive car, but 3 times more powerful, than on the SK-3 combine. The combine with the axial and rotor threshing-separating device at a channel capacity in 10 kg/s has larger weight (with the filled grain bunker – about 30 t) and with a rated capacity of 500 l.h. and above. If the modern wheel tractors weighing 15 … 16 t collect the considerable "protest electorate" because of larger unit loads on the soil and the larger shortages of a harvest connected with it in production, what then to speak about a contribution of thirty-ton combines to deterioration in an ecological condition of productional soil layers? Extent of deterioration of productional processes in agroecosystems becomes apparent.

### Purpose and research problems

To prove system of redistribution of masses in grain-

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harvesting units of the increased and high efficiency, the providing ecological balance of technogenic processes in grain agrotsenoza.

**Research problems**

1. To choose the directions of redistribution of masses in combine harvesters of the increased and high efficiency which realization would provide reduction of the negative impact on parameters of productional processes in grain agrotsenoza;

2. To offer the versions of design technology solutions reducing levels of the negative impacts on the soil;

3. To develop schemes of the harvest units providing decrease in harmful technogenic effects during the harvest works.

The matter is that if the negative impact of wheel tractors masses 15 … 17 t on productional layers of earth (first of all, their reconsolidation, extreme difficulty of driving of soil moisture, as a result, – very frequent droughts for which the natural reasons, as a rule, are not present (Rusanov, 1992; Rusanov, *et al.*, 1994a; Rusanov, *et al.*, 1998; Rusanov, *et al.*, 1994b; Rusanov, 1998)), then combine high-performance harvesters for some reason "are not noticed" in deterioration in ecology of technogenic processes, or just reconciled to these phenomena, or simply "did not manage" to estimate. Huge driving wheels of two-meter diameter, vertical efforts to the leading bridges in 24 … 25 t (in any case, on such loading the famous world combine harvester constructors conducting bridges project), grain bunkers with a ten-ton mass of grain, heavy motor installations with the five hundred-strong engines and a huge radiator (cooling) inventory, with the ton fuel tanks onboard – all this creates much more adverse effect in ecological sense, than 15 … 17-ton four-wheel tractors (besides 28 … 30-ton combines move across the field actually on two wheels, and two others – operated wheels – are auxiliary in this sense).

## MATERIALS AND METHODS

In this problem the technique of researches relies on systems analysis and the theory of systems. It means that in our case to choose the directions of redistribution of masses in the combine harvester, we will be beyond the studied car as system, and in full accordance with theorems of Godel (Kleene, 1957; Lipkovich, 2014; Lipkovich, 2016), "we will rise" in system of more high level – the system of cars including mobile power means of the fifth generation which are now developed, and from positions of system, higher on a rank, we will solve the problem. Similar to we will arrive also at the solution of two remained tasks.

We consider a little sequentially the becoming complicated options.

Option first of redistribution of masses at preservation of the principle of the self-propelled operation combine harvester. Redistribution of masses consists in release of a design of the combine block from the engine and the grain bunker with formation of the self-contained hook-on power unit with the grain bunker with a capacity of 12 … 14 t of grain (the continuous operation of the high-performance combine within 1 hour of removable time). Thus, the monolithic block – the self-propelled combine harvester – breaks up to two: a harvester thresher on self-contained to the course and the block, hook-on to it, from the grain bunker and the power unit mounted on it, – also on characteristic walking frame. In other words, the system – the combine harvester – is distributed on two self-contained running devices that substantially reduces efforts of impact on the soil with a cumulative invariable mass of the mobile harvest unit. The general view of such unit is presented in (Fig. 1).

Here it should be noted that the drive of actions can be carried out by the hydropower unit (Lipkovich, 2013) installed on DVS from the mechanical drive and the electric drive. In our opinion, the hydraulic actuator thanks to the organization of a prime steplessness and existence of all necessary units in hi-tech serial production including in Russia is represented to the most rational.

The second option of the distribution of masses in the grain-harvesting unit is defined by the traditional scheme though which is still not realized in broad grain production. Grain-harvesting MTA consists of the motorless combine (but with the hinged bunker or the bunker in hook-on option) and mobile power means in the form of the traditional tractor of the fourth generation united with the combine the express coupling device (Fig. 2 and 3). Such MTA has tendency to withdrawal, especially with the filled bunker because of the considerable distance between long axes of the tractor and a thresher of the combine which is defined by width capture of a heder (the reaping adapter) and actually creates a big brachium. Let's remind that during creation and serial (mass) production of hook-on combine harvesters of an axis of the tractor and a thresher of the combine were in the common vertical plane in a longitudinal plane of symmetry, and a withdrawal source, considerably smaller in dynamic parameters, it was caused by

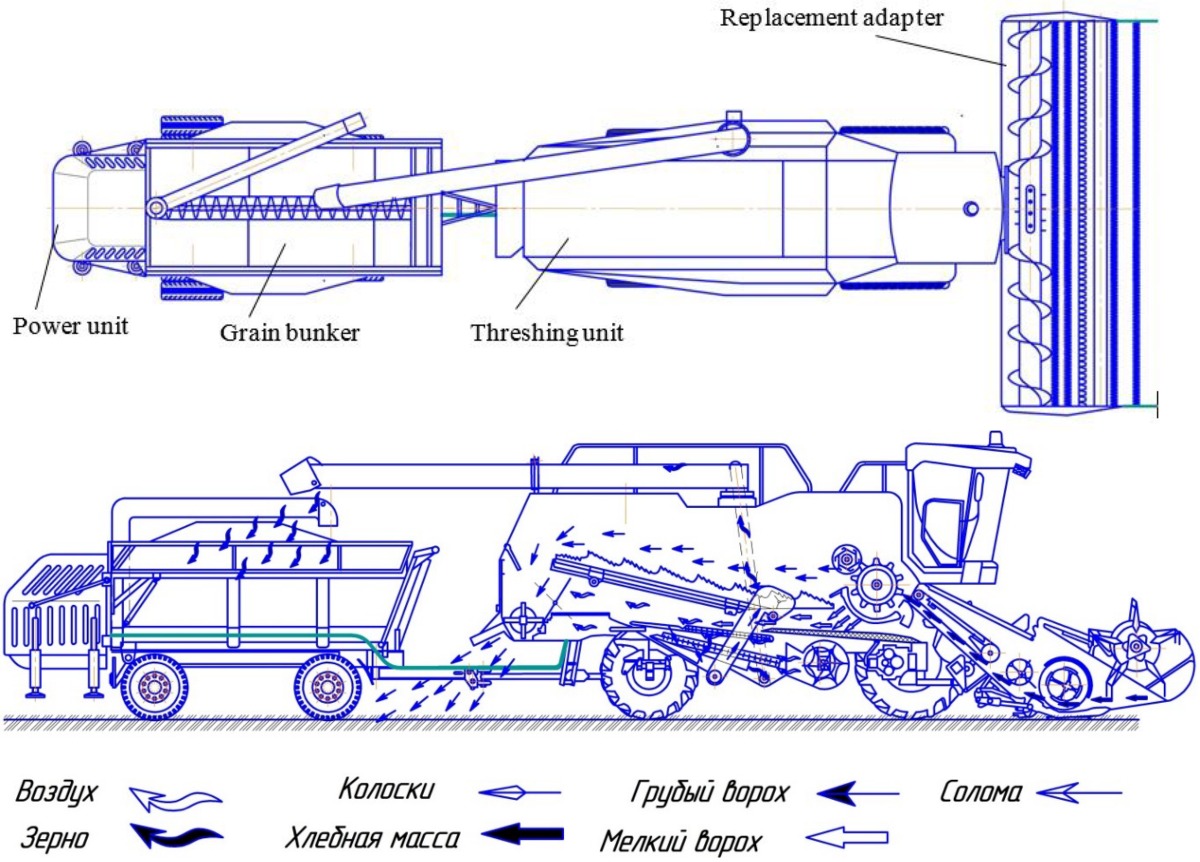


**Fig. 1** The scheme of the self-propelled combine harvester with the distributed weight (the grain bunker and the power station hook-on).

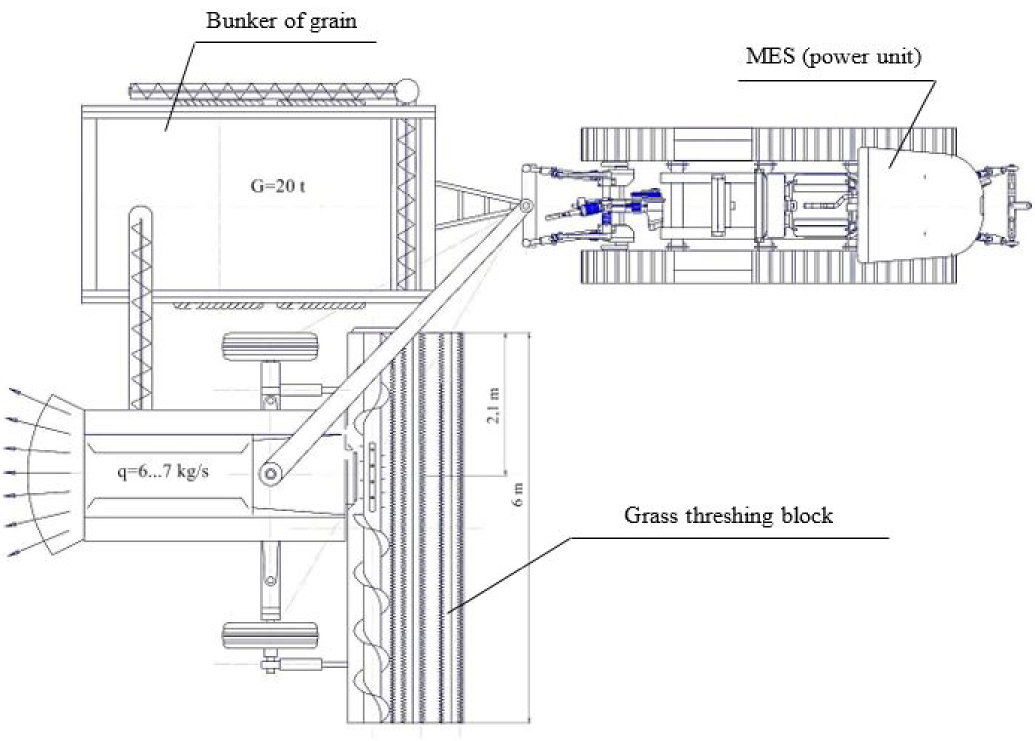


**Fig. 2** The motorless hook-on unit with MES of the fifth generation.

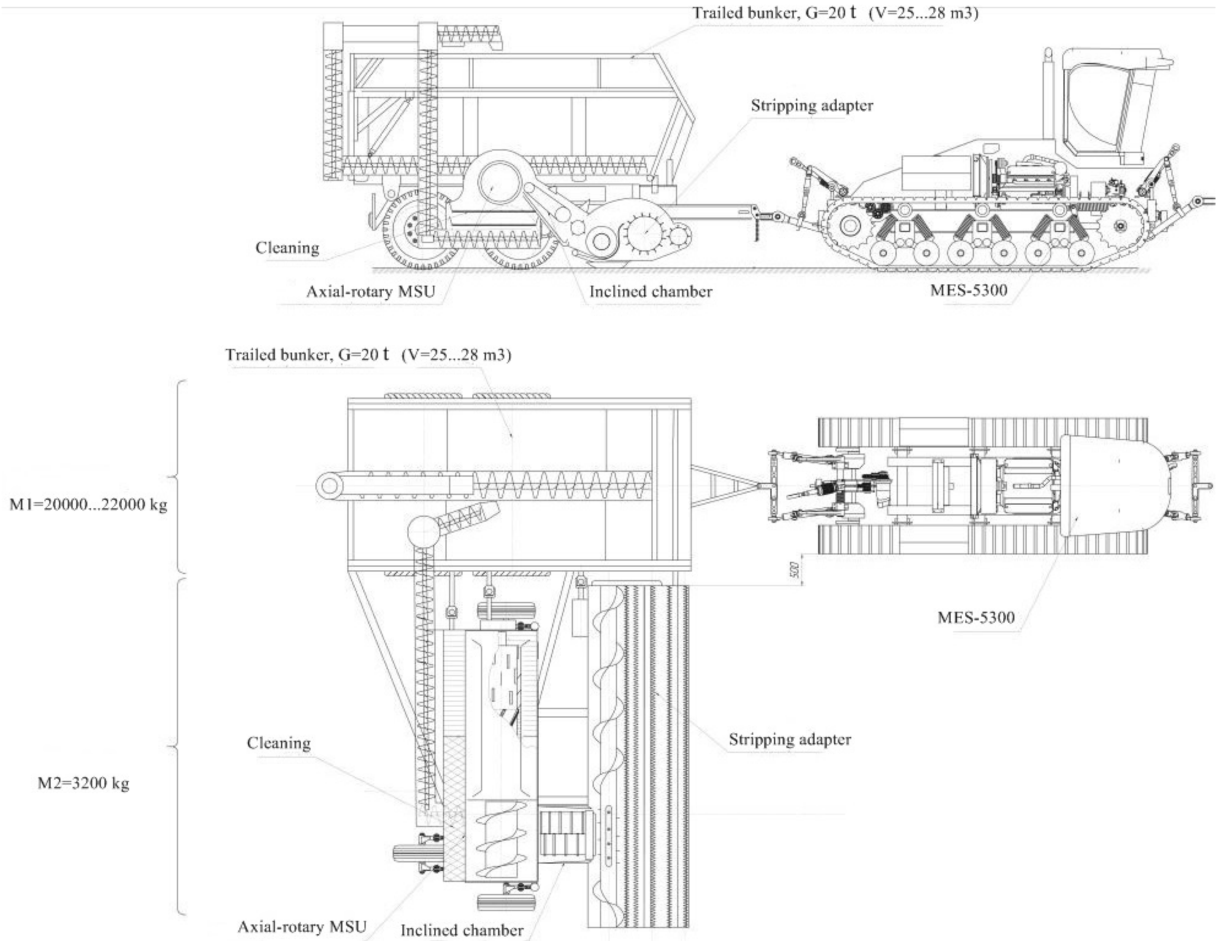


**Fig. 3** Scheme of a non-motorized trailed harvester with a transverse axial-rotary separating device (option).

the Gamma-type (side) scheme of aggregation of a heder with a thresher (The reference book on grain combines, 1959).

The second scheme of aggregation of the motorless combine with the symmetric heder and power machine tractor was submitted by creation of the high-performance RSM-10 combine in the early sixties of the last century; the K-700 tractor, yet not ready to serial production, acted as power means. Its Scheme of the motorless combine with the heavy tractor (the K-700 tractor appeared later) is developed by GSKB of the Rostselmash plant in 1961 … 1962 including one of authors of these lines (Fig. 4). Allowing the considerable sizes of withdrawal (besides the power car was wheel with pivotally the jointed frame), authors of development which carried, undoubtedly, innovative character, at once aggregated with a thresher the feeding pick-up adapter for selection from rolls of slanted leaf-stalks y mass of smaller width, than a heder; serious complications from impact of withdrawal managed to be avoided. Now, using as power means the heavy caterpillar steadier on the linear trajectory, then wheel, it is possible to transfer the offered aggregation option to the actual plane.

The option third of distribution of masses falls into to the complete reconfiguration of molotilny group and harvest MTA in general (Fig. 4 and 5).

First, the threshing group is established crossly concerning axes of mobile power means which long axis, coinciding with the direction of labor movement of MTA, is parallel to an axis of the reaping adapter; thus, axes of the last and threshing blocks are mutually perpendicular.

Secondly, the grain bunker installed on self-contained running system (as well as in the previous case), on the working axis coincides with the direction of the movement MTA, i.e., with a working axis of MES. The bunker is aggregated with transversal blocks of threshing group.

Thirdly, for ensuring stability of forward labor movement (decrease in probability of withdrawal) the threshing block in system of aggregation with MES has the hydromechanical compensator.

Fourthly, to provide technologically self-contained

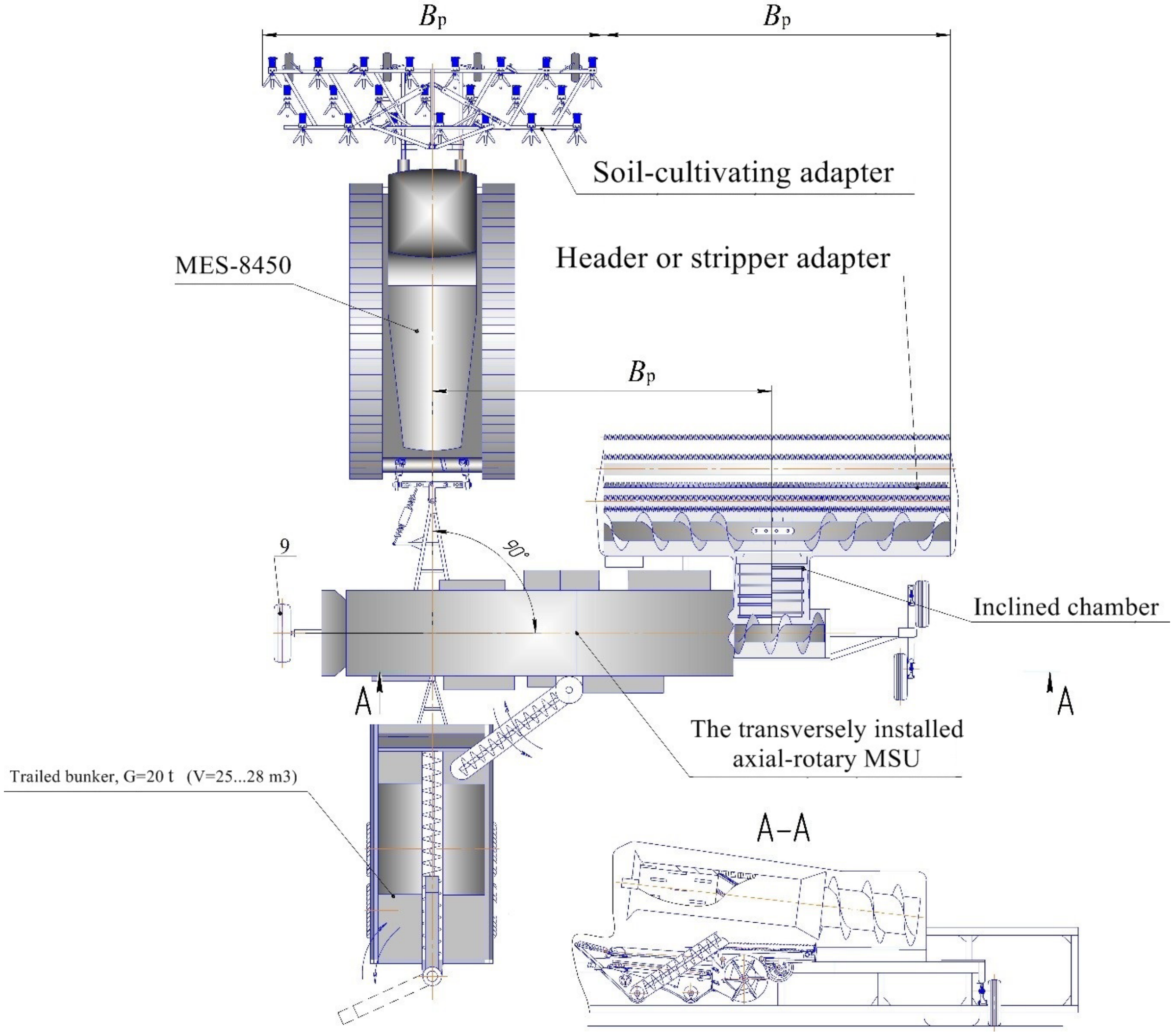


**Fig. 4** The scheme of the motorless harvest unit with axial and rotor local government and the hook-on bunker (working position).

process of cleaning, mainly, of grain grains, MTA is supplied with the adapter for closing of moisture by the surface treatment along with the thresh.

The adapter is aggregated with drive MES by means of the forward hinged device of the last. At last, fifthly, the transport provision of MTA accepts by prime turn of transport wheels on 90o; at the same time the adapter for closing of moisture in harvest process provides transport situation by installation of side wings in vertical position, keeping thereby admissible working width.

The version fourth of the scheme of distribution of masses at synthesis of harvest MTA differs from previous three in essence. The matter is that the unit to the manning in separate terminating blocks not existed. It should collect – to be synthesized – from separate basic clusters, having assumed as a basis complete sets the power car – MES of the fifth generation in caterpillar (in our case) execution.

On MES, in its forefront the adapter for sloping of bread or tow of ears and giving of leaf-stalk weight in system of conveyors with its movement of the thresh is mounted. On the MES back hinged system the block of cleaning of shallow (grain) lots crossly is installed. At last, by means of the hook-on device the bunker executed in the form of the cart on self-contained running system as well as in the previous cases join MES: here differences are minimum.

Thus, the unit is collected. The common packaging scheme of MTA of the fourth option is shown in (Fig. 6).

It is represented to us that the fourth option can be one of the most perspective.

## RESULTS

The negative impact of running wheel systems and

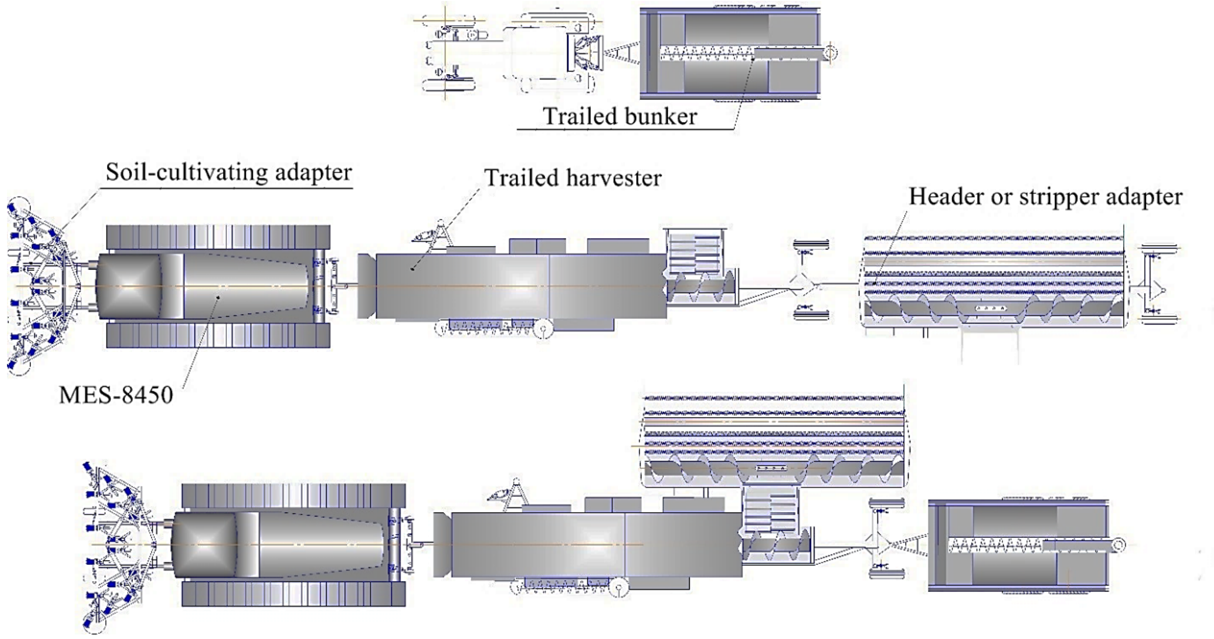


**Fig. 5** The scheme of the motorless harvest unit (according to Fig. 4) in transport situation

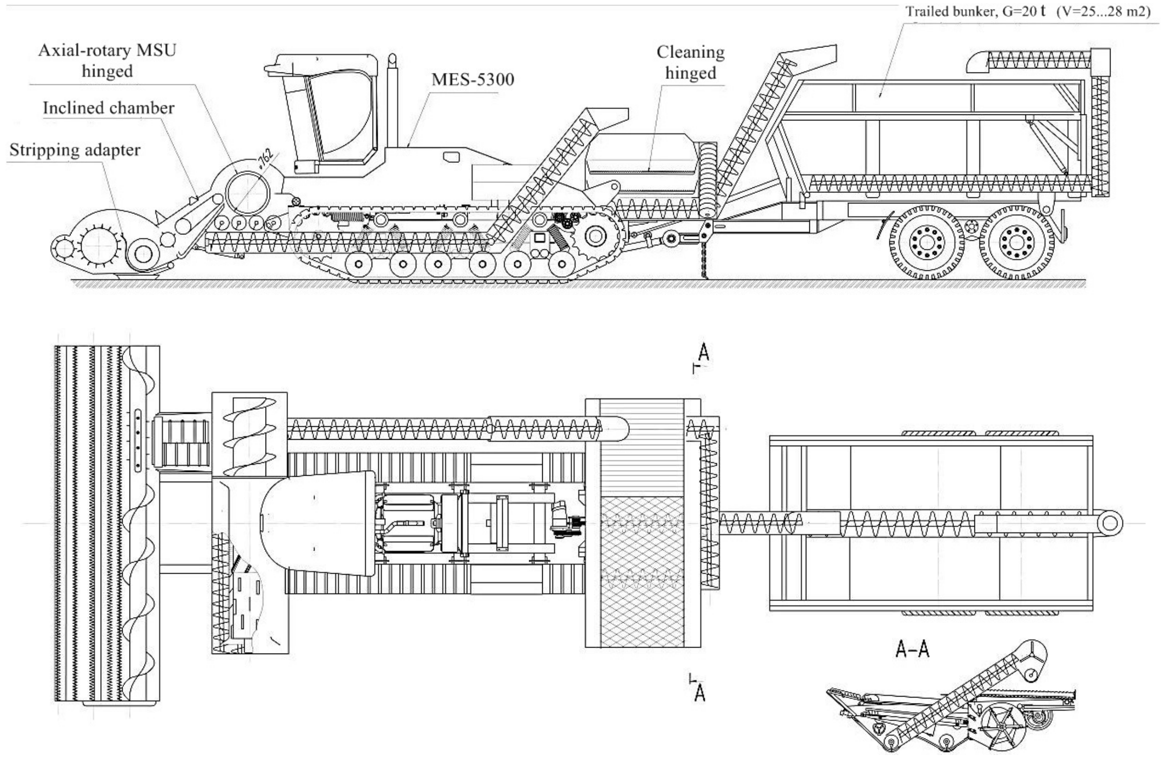


**Fig. 6** Scheme of synthesis of grain-harvesting unit from separate blocks: A - Side view; B - Top view.

design and technological masses on productional layers of soils acts as one of the main problems of environmental friendliness of the modern agricultural machinery (heavy tractors, generally wheel and combine harvesters of a high channel capacity). The consolidation of an arable layer leading to decrease in a harvest increases; there are same phenomena of the condensing character which for a long time the place during the operation of the power saturated tractor high traction class, a little more intensive in view of larger sizes of the moving masses. For the solution of an objective there was a need of transition to system of the following level, – in full accordance with regularities of the theory of systems, i.e. introduction to consideration of more significant, so to speak, AND operations by means of the analysis of systems of high hierarchy to have an opportunity of development of MES of the fifth generation. All four options of the offered redistribution of masses which have to provide balance of technogenic processes in agroecosystems were so proved.

## DISCUSSION

The mass distribution problem in heavy agricultural cars, one of which are combine harvesters of a high channel capacity, – for the purpose of ecological balance of technogenic impacts on productional agroecosystems led to the emergence of the recent scientific trend in the field of mechanization of field works travailled just today. At the same time researches showed that the negative impact of running devices of combines on grocery layers of the soil horizon, generally, much more, than heavy wheel tractors: world tractor construction did not come to level in 24 … 28 t on weight, in any case, under production conditions yet; but combines are more narrow this niche borrowed. To some extent the softening factor in the combine environment represents smaller forward working speeds – as a rule, 5 … 6 km/h in comparison with tractor working forward speeds in 8 … 10 km/h that larger the combine masses to some extent levels levels of the negative ecological impacts. Let's note that, despite sufficient study of a problem, the solution it is still not found: to the wheel tractors considerably deforming an arable layer of earth and reducing harvest size the negative impact of wheel running systems of high-performance combine harvesters increased. Moreover, in an arsenal of creators of extremely necessary basic agricultural cars – high-power saturated tractors and combine harvesters of a big channel capacity – little from efficient tools is. And if in a tractor part of a problem return and even restitution of creation of track laying vehicles (it is impossible to take seriously the comical decision in the form of huge dual wheels with a width of the unit reaching 4 m) is more and more clearly traced, then in combine option possible use of caterpillar running systems is significantly more problematic. Nevertheless, is more narrow by 1959 the semi-caterpillar running device was developed for the self-propelled S-4 combine for the purpose of increase in permeability (the car was produced in lots) (The reference book on grain combines, 1959). Then still – 60 years ago – it was not supposed that the called running device will be necessary to superheavy combines which just were not yet, – for decrease in harmful effects on the soil. And this idea glimmers so many years, and now is again demanded in Russia and some foreign firms; it is possible to point also to use of the complete caterpillar running device for combine harvesters which is exclusively used as to increase in permeability, for example, on rice cleaning, and to preservation of quality of an arable layer and ecological balance of technogenic processes in general.

But the system of caterpillar and semi-caterpillar running devices has also characteristic shortcomings.

First, it is very bulky even if to consider the modern design technology solutions. Secondly, as semi-caterpillar, and – especially – the caterpillar running device has the quite considerable masses which considerably exceed wheel running couples. At the same time the drive of a caterpillar drive very difficult gives in to unification if to use the last with metal and even caterpillar tapes. At last, thirdly, the caterpillar (semi-caterpillar) running device is quite expensive, and for quantity or large-lot production in agricultural mechanical engineering of any country it will be very burdensome and hardly demanded in the market.

Therefore, we also put a problem of redistribution of masses in a design of grain-harvesting MTA as the instrument of ecological balancing of technogenic processes in agroecosystems. The carried-out calculations showed that even in case of use of a method of redistribution of masses in the complete self-propelled combine (option first) the price of the last will remain in traditional area of existence. If to consider MTA option with the motorless combine understaffed with mobile power means, then a technological part: actually, the combine with actions – will have market price, commensurable with the price of the complete self-propelled grain-harvesting unit.

The offered four versions of schemes MTA, generally, solve an objective (especially motorless options) with the distributed masses, having at the same time novelty by definition: redistribution of working mass of combine harvesters has to provide ecological balance of technogenic influence of running systems and the relative frame mass of high-performance combines on quality of functioning of productional agroecosystems.

## CONCLUSIONS

1. Development of agricultural mechanical engineering, increase in a simple channel capacity of basic technique, reduction of duration of harvest works and decrease in losses of the grown-up harvest are followed by reconsolidation of productional layers of soils, education in the soil horizon of the surfaces

interfering compound of subsoil and atmospheric moisture, deep zones of padding consolidation: it causes sudden droughts, expansion of zones of risky and droughty agriculture. One of options of removal of a problem lies on the ways of the redistribution of mass of the working and subsidiary bodies directed to change of design flow diagrams of harvest MTA.

2. Return to use of hook-on motorless harvest units relies on creation of new generations of a mobile power engineering of high power, application of new methods of constructioning, the innovative evidence-based principles of synthesis of complex harvest the units entering the finished multiprocess operations with their help.

3. Creation and application of hook-on motorless harvest MTA will provide the considerable decrease in capital investments in harvest technique, will raise seasonal load of high-power saturated caterpillar MES of the fifth generation, will reduce costs of production of a harvest, will significantly improve an ecological situation in productional processes also the agrotsenozakh, and thus, will solve a common problem of ecological balancing of technogenic processes in agriculture.

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