The choice of a promising scheme of transport technological agricultural energy

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Abstract. An important issue in the creation of transport technological energy means for agricultural purposes at the stage of research and development is the statement of the problem taking into account the technology of cultivation of the corresponding crop. What are the main provisions for choosing the concept of this type of equipment and what you need to pay attention to when designing them for specific conditions. The article presents the results of experimental studies, pilot industrial and production tests of various machines and assemblies with structurally adaptive mechanisms. The analysis showed that their application provides a wide range of regulation and self-regulation of the unit operating modes, increased reliability and performance, simplicity of design and ease of use, which confirms the feasibility of their use in agricultural production.

1 Introduction

An important issue in the creation of transport technological energy means (TTES) for agricultural purposes at the R&D stage is the statement of the problem taking into account the technology of cultivating the corresponding crop. What are the main provisions for choosing the concept of this type of equipment and what you need to pay attention to when designing them for specific conditions.

It is widely known that agriculture needs thermal power plants designed to meet the characteristics of operation in agriculture. Currently, the main trends in their development are clearly traced. These trends relate primarily to increasing power, expanding operational functions, hydrofication of power drives and control drives, automation of control and regulation of individual operations, as well as deepening the principles of universalization and modularity at various levels, etc. [1-6].

However, even at the stage of choosing a technical solution, it is necessary to determine the range of technological operations that this TPP should provide, including, of course, certain attachments here to provide for the entire range of necessary technological operations.

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2 Materials and methods

All agricultural work performed can be divided into several main technological groups: tillage, sowing, harvesting, fertilizing and chemical plant protection.

Let us consider in more detail the entire technological operations in field cultivation.

Tillage. The main task of soil tillage is to create favorable conditions for the development of cultivated plants in order to obtain high and sustainable crops. Distinguish between basic, special and surface tillage. The main treatment is plowing with or without formation rotation. Sometimes plowing is combined with simultaneous loosening of the lower soil layers.

In areas subject to wind erosion, the main tillage consists of cultivating plow cultivators or cultivators, ploskorezami.

Deep tillage according to the method of T. S. Maltsev consists in loosening by plows to a depth of 35 - 40 cm without a turnover of the formation. This treatment is carried out once every five to six years.

Special processing includes plowing virgin, bog soils, planting and longline plowing, deep cultivation, soil milling, drilling holes for planting trees, etc.

Surface treatment involves the following operations: peeling, harrowing, loosening, cultivation, rolling, hilling, cutting ridges and crafts ridges (in areas of excessive moisture), etc.

In connection with these operations, three groups of tillage machines and implements are distinguished:

- tractor plows and other general purpose machinery and implements for basic tillage;
- plows and other special purpose machines and implements;
- machines and implements for surface tillage.

Machines and implements for surface tillage are divided into the following groups:

- harrows (tooth, mesh, harrow train, disk, etc.) and disk cultivators for loosening the soil, weed control and leveling the surface of the field;
- cultivators for continuous and inter-row tillage;
- rollers for soil compaction, crushing lumps and leveling the surface.

According to the method of connecting with tractors and self-propelled chassis, tillage machines, mechanisms and implements can be mounted, semi-mounted and trailed. It should be noted that, as a rule, mounted machines and implements are 1.5 - 2 times lighter than trailed ones, much simpler in design, and their productivity is higher than trailed ones.

Sowing. Several methods of sowing are now known. Each of them is applied in certain conditions and is associated with a specific culture. The following methods of sowing and planting are used: ordinary, narrow-row, cross, ribbon, wide-row, nesting, square-nesting, dashed, rowless and scatter.

For the sowing operation, seeders are used, which are classified according to the following criteria: the method of sowing, the purpose and method of aggregation with the tractor.

According to the method of sowing, ordinary, narrow-row, nest, square-nest, dotted (precision sowing) and scatter (for grass and fertilizer seeds) seeders are distinguished.

According to the purpose, the seeders are divided into the following groups: for sowing grain crops, including grain seeders with devices for sowing mineral fertilizers, grass seeds and other crops (grain-fat, grain-grass); for sowing row crops (corn, beets, cotton, etc.); linen; vegetable; special purpose (forest, meadow, greenhouse).

According to the method of aggregation with a tractor, seeders are distinguished as trailed and mounted.

Harvest. The next, important group of works is the harvesting of the grown crop. Grain crops can be harvested in two ways: with the use of combine harvesters (combine

harvesting) and simple reaping machines, followed by threshing with stationary threshers or combines from the driveway or porch. The main one is the combine harvesting, which can be performed two-phase (separate combining) and single-phase (direct combining).

Harvesting using simple reaping machines is multiphase (with a large amount of transshipment and transport work, accompanied by crop losses) and is currently used only in small areas of irregular configuration with uneven terrain and in adverse weather.

With direct combining, mowing and threshing of bread is carried out simultaneously: in one pass, the combine performs all operations. Harvesting by direct combining is carried out at the stage of complete ripeness of the grains.

The possibility of harvesting bread in one way or another depends on a number of circumstances: the agrobiological properties of the crop, weediness, density, stalk height, condition of the harvested crop, harvesting dates, weather conditions, the presence of machines on farms, etc. As practice has shown, separate two-phase combine harvesting is reliable a means of preventing losses occurring during direct combining. With separate combine harvesting, harvesting begins 5-10 days earlier than with direct combine harvesting, at a time when most of the grain is in the stage of wax ripeness. As a result, the bread is mowed under more favorable conditions, which leads to a sharp reduction in grain losses and an increase in its collection.

Depending on the purpose, all grain harvesting machines can be divided into the following groups:

- 1) reapers for mowing bread mass and the formation of rolls;
- 2) harvesters with pick-up and stacker for selection and threshing of rolls;
- 3) combines for mowing and threshing grain mass;
- 4) machines for collecting, transporting and storing straw products (stacking balers, balers, shredders, stacking balers, trailers, stackers, stackers, bale pickers, etc.);
- 5) machines for post-harvest grain processing (heap cleaners, grain dryers, cleaning and sorting machines, etc.).

Combine harvesters are designed for harvesting grain and leguminous crops in a separate way and direct combine harvesting. Combines are self-propelled, mounted and trailed. The self-propelled combine is equipped with an engine that drives all the working bodies and reports the movement of the chassis. Mounted combines are mounted on self-propelled chassis. The working bodies of the mounted combine are driven by the chassis engine

Fertilizer application. In agricultural practice, the following methods of fertilizing the soil have been applied:

- Fertilizing before sowing and planting by continuous sieving on the surface of an unplowed field, on winter crops in early spring, or on winter swellings before pre-sowing cultivation. About 2/3 of all mineral fertilizers are applied in this way. Organic fertilizers are scattered on the surface of an unplowed field, and then smelt;
- Fertilizing in rows along with seeds or tubers or next to them when sowing. To do this, on the seeders and planters, devices for ordinary or nest fertilizing are installed;
- fertilizing the soil during plant growth (top dressing). Usually, fertilizing is combined with the cultivation of row-spacings.

In accordance with the methods of fertilizer application, the machines are divided into three groups:

- 1) spreading machines for surface screening of fertilizers - fertilizer seeders and spreaders;
- 2) combined seeders and planting machines for fertilizing during sowing;
- 3) machines for dry and liquid top dressing of plants - cultivators, plant nutrients, etc.

Chemical protection of plants. Consider the main types of hardware designed to perform this group of work.

Sprayers are designed for spraying and applying pesticides in a finely sprayed state on plants to control their pests and diseases, destroy weeds and to disinfect rooms. Sprayers apply pesticides in the form of solutions, emulsions, suspensions or extracts of various concentrations in a finely divided state. The following basic agrotechnical requirements are presented to sprayers. Spraying devices should provide the most uniform (by the size of the droplets) spray of liquid, complete and uniform spraying of the whole plant or certain parts of it, depending on the location of pests or the sites of disease damage. Sprayers must accurately dose the pesticides, maintain the required fluid flow rate per unit area and a uniform concentration of pesticides over the entire period of emptying the tank, regardless of the speed of the unit. Sprayers should have good maneuverability, maneuverability and stability in work, not to damage the processed plants.

By appointment, the sprayers are divided into special (for vineyards, orchards, hop plantations, etc.) and universal. By the type of spraying devices they are hydraulic, fan and aerosol, by the method of driving into action and moving during operation - backpack, horse, horse-motor, tractor, automobile and aviation.

3 Results and discussions

For the most successful functioning in terms of the tasks set, the universal energy facility (UES) should be aggregated with working equipment and technological modules in accordance with the scope. Let us consider the formulation of aggregation problems in more detail.

A machine-tractor unit for agricultural purposes based on a TTES is formed when connected to a tractor with various agricultural equipment and the introduction of the corresponding working equipment into the design of the electrical resistor. The working equipment [7] in this case includes:

- hydraulic system, including hydraulic manipulators, hydraulic outlets, pneumatic outlets, etc.
- towing devices;
- power take-off shafts, electrical leads, winches and drive pulleys.

Work equipment can also include manipulators, loading buckets, bulldozer dumps, grabs, skidders, etc.

The aggregation system includes a hinged system designed to connect electrical resistors with mounted machines and control their position, trailed devices for towing trailed machines and a power take-off system for driving the working bodies of aggregated machines bypassing the chassis.

Depending on the method of aggregation, TPPs can be trailed, mounted, semi-mounted and combined. In the latter case, several machines are connected in different ways to the electrical resistor.

Trailer devices are used to aggregate electrical resistors with trailed and semi-trailed machines. They can be tough and manageable. A rigid tow hitch is a hook, an arm, a spherical support or an automatic coupler element, mounted on the rear of the tractor skeleton. Hydraulic hitching devices are more convenient, allowing you to adjust the position of the hook with a hydraulic cylinder.

Unlike mounted equipment, the trailer is located only behind the tractor and always moves in traction mode. The mounted equipment can be located on the chassis of the electric power station in various places and move both in traction and in pushed modes.

Some mounted machines and implements, such as plows, may have support wheels that regulate the depth of tillage, but only a small fraction of the weight is transferred to them.

According to the location of the mounted machine relative to the tractor, the front, central, side, rear and combined hitch are distinguished.

With a front linkage, an aggregated machine or implement is placed in front of the tractor, for example, a dozer blade, a roller header, a brush cutter, and a front loader.

With a central hitch, the aggregated machine is placed under the UES chassis. It can be for example a cultivator, a mill, a pumping unit, etc.

With a side hitch, the aggregated machine is placed on the side of the tractor. This can be a mower, sprayer, channel digger, etc.

With the rear linkage, the aggregated machine is located behind the tractor. This can be a plow, harrow, seeder, and other tillage tools.

Some devices may have a combined mount. For example, a bulldozer blade is installed in front of the UES, and a manipulator in the back.

The combined hitch can be used for sprayers: consoles with sprayers are installed on the sides of the electrical resistor, the pump is on the bottom, and the tank for toxic chemicals is on the back.

Power take-off systems are designed to drive active working bodies of machines aggregated with electrical resistors. Mechanical and hydraulic power take-offs are used, and in some cases, electric and pneumatic.

In particular, a mechanical power take-off system transmits the power of the electrical resistivity engine to the working bodies of the machine's TTES through a mechanical transmission system. The final element of the mechanical power take-off system is the power take-off shaft (PTO). The output shaft of the power take-off shaft is connected to the power receiving shaft of the aggregated machine.

Distinguish between independent, semi-independent, dependent and synchronous PTO drive modes. With an independent PTO drive, the power flow is separated before the main transmission of the electrical resistor, which allows the aggregated machines to be driven regardless of whether the thermal power plant is moving or stopped, as well as turning, turning off and changing the speed of the PTO during movement. The semi-independent PTO drive is distinguished by the fact that it does not allow turning it on and off when driving.

With a dependent PTO drive, power flow is separated after the main clutch (or torque converter). The dependent drive is structurally simpler than the independent one, since it is carried out from one of the transmission shafts, but does not allow the drive of aggregated machines with the clutch off, and the PTO can be turned on and off when driving. With a synchronous PTO drive, power is taken from the main gear and the PTO rotation is consistent with the speed of movement.

An independent PTO drive is used when working with machines, the speed of rotation of the working bodies of which should not depend on the speed of the TTES. Such machines include various mounted and trailed combines, trenchers, pump and compressor devices. Synchronous drive - for work with sowing units.

A number of tractor models have several power take-off mechanisms, the output shafts of which can be placed at the rear, side, and front of the TPP.

The hydraulic power take-off system (GPS) transfers the power of the tractor engine to the working bodies of the machines through a fluid flow. At its core, a GPS is a hydrostatic transmission. It differs from a hydraulic hinged system in that it can operate in conditions of a constant flow of fluid through the hydraulic motor of a driven unit. It is widely used on modern tractors to drive the working bodies of complex agricultural and communal machines. The GPS includes a hydraulic pump (axial-piston or radial-piston type, less often gear), a reservoir for the working fluid (most often oil, but there may be other fluids), a radiator for cooling the working fluid, distributor, and couplings. The advantage of the GPS is the ability to smoothly control the speed or speed of movement of the working bodies,

the possibility of independent distribution of power to a large number of working bodies, the possibility of automation.

In [8], the orientation to the total power of the machine is directly called a typical mistake when choosing a tractor, while the power on the PTO and the performance of the hydraulics (oil pump) are important for the efficient operation of the equipment: "Often, thinking about the power of the engine, they forget what it is at the output, and incorrectly calculate the power necessary for the operation of the tools or for the drive of active attachments" [8]. This is especially true for modern horticulture and viticulture, where it makes sense to use specialized energy-saturated machines because gardening involves the use of a huge number of mounted and trailed equipment.

"The task of gardeners and winegrowers is to load an existing tractor with implements in full, to use it with the maximum possible and affordable number of units," it says [8]. Aisle care work (loosening, tillage, mulching, etc.), spraying, vine and twig care (chasing, pruning, cropping, etc.), thinning flowers, picking directly - all this can be done with using various mounted equipment. So, the tractor must have high power" [8]. In addition, for the full and effective use of attachments, it is necessary that already from the factory the tractor for gardening and grape work should be equipped with the maximum number of hydraulic outlets: in the front, rear and side parts of the machine.

"In gardening, there are a lot of active mounted processing tools with a hydraulic drive of working bodies," it is said below [8]. Cutting, leveling, chasing, leaf removal and other operations are mainly done with tools designed for a stable and powerful flow of hydraulics. And if it is planned to use several tools or units at the same time, requiring a large flow of oil, then it is necessary to order machines from the factory with increased hydraulic pump capacity."

For example, in specialized Deutz-Fahr grape tractors, up to 7 pairs of hydraulic outlets can be installed (in total in the front, rear of the tractor and side pairs).

In this regard, it is worth turning to the practice of using structurally adaptive mechanisms [9]. At present, adaptive 2- and 3-moment distributors with 2 and 3 PTO, respectively, are already used. It is theoretically possible to create adaptive p-moment distributors incorporating n differential three-linkers.

To expand the number of control ranges of the output parameters, simplify the design and reduce the mass and dimensions of adaptive p-moment distributors, it is possible to use composite and complex adaptive moment distributors [10].

A typical technological process of agricultural transport-technological machines can be described by the following generalized model. Such model (Figure 1) is a multidimensional object, exposed to random influences with a complex interrelation of input and output parameters, which can be divided into the following groups:

a) the group of input parameters includes, firstly, unmanaged parameters $x_1, \dots, x_i$, which are technological and structural parameters, determined by the working body and machine tool (type of the working body, type and geometry of the tool, etc.), and secondly, adjustable operating parameters, which act as regulatory influences. The latter include traction force, the speed of movement of the executive body or tool, the speed of rotation of active disks or soil cutters, etc. They are denoted as $y_1, \dots, y_i$;

b) the group of output parameters $v_1, \dots, v_n$ includes resistance forces, power (moment) consumed by the engine, the speed of movement of the machine or the executive body, specific energy consumption, tool durability or wear rate, productivity, specific cost, etc. It should be noted that the parameters of the output group, in fact, they characterize the efficiency of the process, essentially depend on the chosen variant of controlling the course of the technological process;

c) the group of disturbing influences $z_1, \dots, z_m$ includes the effects of the external environment, depending on the physic mechanical properties of the treated array, including uneven ground surfaces, the presence of solid inclusions, soil sticking and other factors.

A model of a typical process is shown in Figure 1.

Fig. 1. Model of a typical technological process.

4 Conclusion

The results of experimental studies, pilot industrial and production tests of various machines and units with structurally adaptive mechanisms showed that their application provides a wide range of regulation and self-regulation of the unit's operating modes, increased reliability and performance, simplicity of design and ease of use, which confirms the technical and economic feasibility of their use in agricultural production.

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