Working bodies of a moldboard plow for combined soil processing with a turnover of a layer

Sergey V. Belousov[1,*] and *Alexander A.* Tsymbal[2]

[1]Kuban State Agrarian University named after I.T. Trubilin, Krasnodar, Russia
[2]Russian State Agrarian University of Moscow Agricultural Academy named after K.A. Timiryazeva, Moscow, Russia

Abstract. The paper shows the issues of moldboard tillage with simultaneous additional cutting of a wrapped layer with disk working bodies. An overview of the main disk working bodies used in agriculture is given. The technical solution of a combined arable unit is proposed and the technological process of its operation is presented. A brief description of the laboratory and field installation is also presented.

Plowing is necessary to saturate the soil with oxygen, mix the elements, dispose weeds and improve the soil structure. The material of soil processing is characterized by physical and mechanical, technological and technical and economic properties.

Chemical and physico-biological processes occurring in arable and sub-arable layers depend on the quality of moldboard tillage, which affects the yield of cultivated crops.

We propose to modernize a moldboard plow, which is designed for soil plowing with a reservoir turnover to a depth of 30 cm for various crops, in fields that are not clogged with stones, flagstones and other obstacles. The tasks of tillage performed by us are necessary to create optimal conditions for plants, which are solved in various ways [1, 2].

The method of mechanical tillage of soil is a type of influence of working bodies on the change in a profile and structure of a treated layer. There are moldboard, moldboard-free, rotary and combined methods.

Plowing is loosening, crumbling, and wrapping of a cultivated soil layer in order to increase the natural fertility in a cultivated layer without changing the genetic composition by introducing chemical and biological trace elements [1, 2].

The most promising designs are considered to be combined tillage units, the use of additional DRO working bodies in the form of disks. These developments are widely used in combined units [2].

Our work is carried out in accordance with the plan of scientific works in accordance with the Agreement between the FSBEI HE "Kuban State Agrarian University" and FSBSI "Agrarian Scientific Center "Donskoy" of Zernograd.

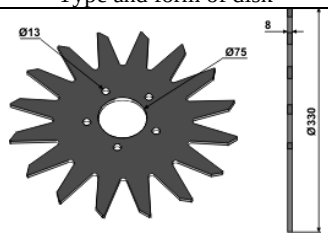
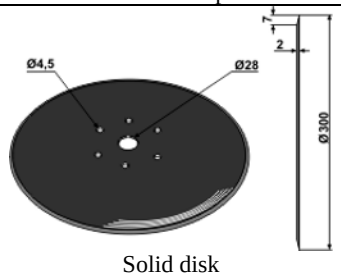
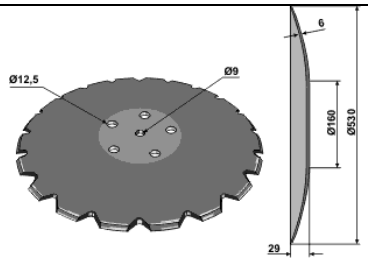
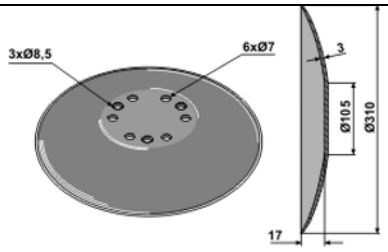
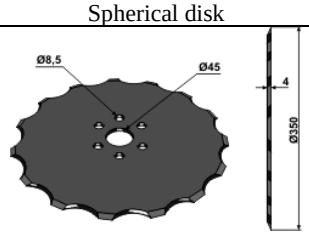
According to results of the analysis of scientific researches of scientists, it is considered that the developments of Federal State Budgetary Scientific Institution "Agrarian Scientific Center "Donskoy", the department "North Caucasus Research Institute of Mechanization

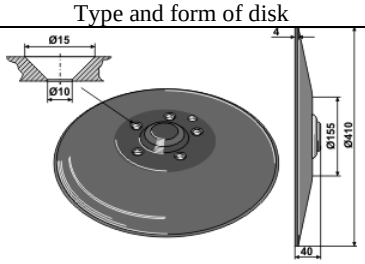
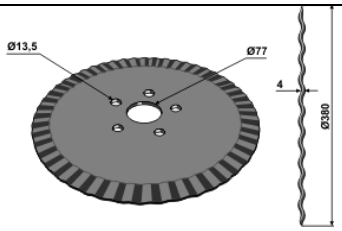
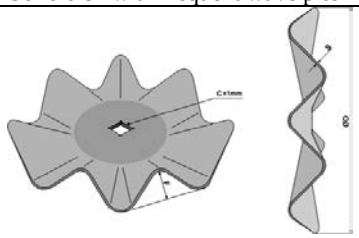
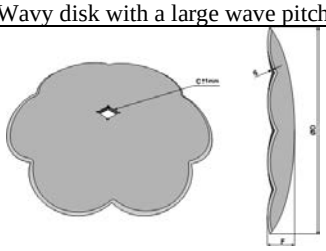
* Corresponding author: sergey_belousov_87@mail.ru

and Electrification of Agriculture", Zernograd, Pakhomov V.I., Rykov V.B., Kambulov S.I., Doctors of Sciences, are the most promising and when using various variations of moldboard working bodies, positive results were obtained in their use in cultivation of agricultural crops.

Table 1 shows the various forms of disk working bodies that are widely used in tillage, their purpose is shown as well [3].

Table 1. Purpose and form of disk working bodies.

№	Type and form of disk	Use
1	 Solid disk in the shape of a star	It is used in disk rollers as an intermediate link for creating additional stresses in soil horizon and cutting crop residues.
2	 Solid disk	It is used as additional working bodies in disk harrows, it grinds crop residues actively.
3	 Toothed disk with a flat socket	It is used as working bodies designed for active grinding of crop residues and closing the moisture in soil after harvesting grain crops.
4	 Spherical disk	Such huskers and disk harrows are used in battery-type tools. It is used when creating a mulching layer for further sowing.
5	 Toothed flat disk	Toothed flat disk is easily plunged in soil, but it crumbles soil badly as the depth of its processing increases

№	Type and form of disk	Use
6	 Shaft disk	Such huskers and disk harrows are used in battery-type tools. It is used when creating a mulching layer for further sowing.
7	 Solid disk with frequent wave pitch	Part of the disk surface is made wavy to ensure smoothly repeating changes in the angle of attack from its original value. The wave of the disk, starting from the cutting edge, is made decreasing to the center of the disk with the transition to the sphere.
8	 Wavy disk with a large wave pitch	It is installed on heavy harrows in the form of batteries. It is used for processing heavily clogged fields after harvesting corn and sunflower. The wave of the disk, starting from the cutting edge, is made decreasing to the center of the disk with the transition to the sphere.
9	 Disk «Romashka»	They are installed on heavy disk tools of the BDT-7 battery type and their analogues.

Disks, both with passive and active drive, are used as the main and additional working bodies in disk huskers, plows, tuber harvesters and other machines. If the passive disk moves along the soil surface without sinking, then we can say that in this case the disk rolls without sliding and slipping, the instantaneous center of velocities is located at the point of contact of the disk with soil surface. When the disk moves with a slip, the instantaneous center of velocity is located on the straight line connecting the center of the disk with the point of contact of its blade with soil surface.

As the circumferential velocity increases, the instantaneous velocity center approaches and coincides with the center of the disk. If the disk moves with a slip, the instantaneous center of velocity is below the point of contact of the disk blade with soil surface. In the process of plunging the disk into the soil, its resistance increases. This suggests that the kinematic parameter will decrease with increasing depth.

The results of experiments of leading scientists show that as the freely rotating disk is plunged into the soil, the resistance increases. This hidden pattern is determined by friction forces acting on the blade and the side surfaces of the disk. If we give the disk to force rotation without taking this phenomenon into account, then the rotation mode may be such that the disk itself will tend to rotate the drive shaft and, due to the circulation of intermediate power in the transmission, there will be overloads, and it was decided to abandon such complex structures.

We propose to install a battery of disk working bodies on individual ridges directly behind each body of the plowshare, namely, behind the blade, so that the battery grinds the wrapped layer of soil with the plow body and thereby gives it a more finely lumpy structure Figure 1.

The essence of the technical solution (Figure 1) is that we install a battery of disks 9 on the individual ridge 7, 8 directly behind each body of the plow. The working body is made in the form of a solid disk with cutouts in the middle part to reduce the metal consumption and weight of the structure. The ridges 7, 8 have a hinged design 10, which allows you to transfer disk batteries to the transport position without disconnecting them from the arable unit.

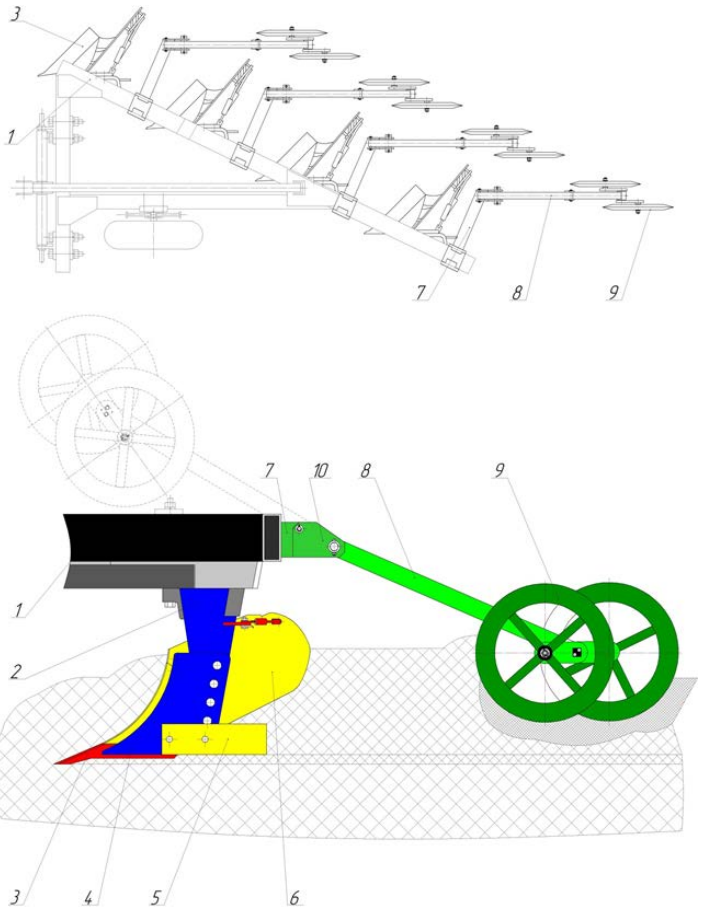


Fig. 1. Scheme of a combined plowshare. Patents №188556, 188094, 188551, 188558, 189846

The device for tillage works as follows [4]:

The moldboard plow, penetrating into the soil with bodies consisting of rack 2, ploughshare 3, boot 4, field board 5, moldboard 6, cuts off the soil layer and lifting it along the moldboard 6 of the body, wraps it to the bottom of a furrow, fixed on the plow frame 1 on individual ridges 7,8 of batteries of disks 9, penetrating into a wrapped soil layer with their cutting edges, crumble it into smaller fractional components, and thereby giving a leveled structure to the field surface, closing moisture in it, and weeds, embedded in the bottom furrow, have no connection with external environment, which leads to their natural death [3, 4].

Table 2. Brief characteristics of laboratory-field unit.

Parameter	Value
Gripping width of one plow body, cm	35
Gripping width of the whole unit, cm	140
Diameter of used disks, mm	420, 510
Tractor for tests, kWt (MTZ-1221 and analogues)	97

The definition of design parameters of a moldboard plow with rotary working bodies consisted in the fact that additional rotary working bodies are mounted in the form of batteries of disks, the geometric parameters of which are limited only by the length of the ridge and the angle of attack**.**

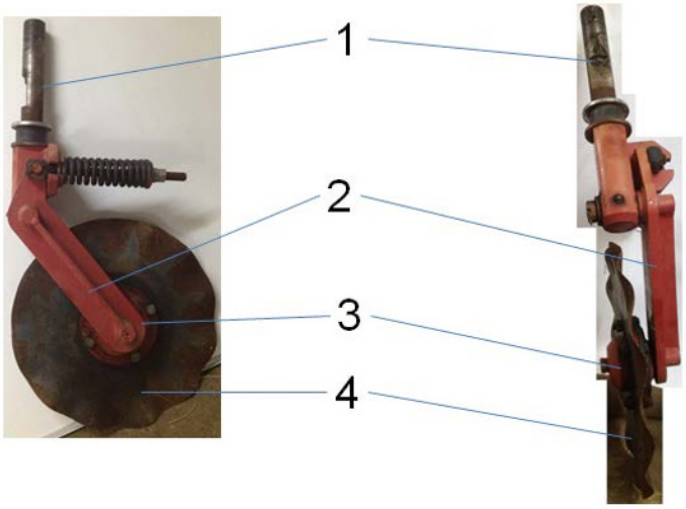


Fig. 2. Disk working body (experimental sample)

The section of disk working bodies is assembled on the basis of the movable rack 2 of the bearing unit 3 and the wavy disk 4 (Figure 2). Sections made up of these disks have the ability to install both one and two disks on both sides of the rack, forming a disk battery, while the operation of each disk will not depend on the other [5, 6].

These studies are intended to establish the regularities of changes in the kinematic parameter of the disk at different depths, as well as depending on the size of the diameter when interacting with soil, and to develop a method of analytical calculation of forces acting on the disk to establish the regularities of changes in energy parameters from operating modes and its diameter.

The theoretical method of research is based on the use of literary information sources, theoretical mechanics, analytical geometry and classical methods of mathematics.

The experimental method is based on model and laboratory – field experiments. Experiments on the study of the kinematic parameter will be carried out directly in the field in the established agrotechnical terms [7].

In this paper, we have proposed a technical solution for a combined moldboard arable unit for additional cutting of a wrapped soil layer. This method is effective, since by combining technological operations, we achieve a reduction in the passage of aggregates through the field when preparing the soil for sowing. Using the proposed technical solution, an additional effect of cutting the wrapped layer is achieved, and the installation of wavy disks on individual ridges and racks will additionally ensure the copying of the relief of wrapped furrows and, as a result, perform soil processing more effectively.

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