

Overview of milling implements for grinding trees and shrubs

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Abstract. The article describes the main consumers of milling tools (mulchers and rotovators) in the context of the sectors of the national economy, considers the classification features and features of the design and layout of these tools on energy carriers. The range of the main manufacturers of milling tools in the Russian Federation, the Republic of Belarus, countries of near and far abroad is described. It is noted that, despite the effectiveness of the use of tracked vehicles in a number of operating conditions, about 95% of this equipment has a wheeled propulsion type. Special attention is paid to the delimitation of the scope of mulchers and rotovators, as well as the possibility of using disk attachments for shredding trees and shrubs.

1 Introduction

At present, a number of enterprises face the acute issue of increasing the level of mechanization of the work performed. This is achieved through the introduction of advanced technologies and modern equipment. This primarily concerns the need to care for power lines, gas and oil pipelines, and the implementation of a number of forestry activities. In recent years, the usual brush cutters and uprooters have been replaced by milling tools (mulchers and rotators) [1, 2, 3], which are hung on various base chassis [4, 5, 6, 7, 8]. This technological equipment is produced by a number of manufacturers, both in our country and abroad.

2 Materials and methods

Over the past 10 years, milling tools and machines, primarily mulchers and rotators, have become widespread due to their high versatility and cost effectiveness. At the same time, based on the terminology, the mulcher or "forest cutter" is intended for clearing the area from tree and shrub vegetation on the vine without collecting wood chips, which are scattered over

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the surface of the earth. If the milling tool works with immersion into the ground (it is used for uprooting, preparing the soil for planting, etc.), then it is called a Rotovator [8].

The use of machine technology for clearing cutting areas makes it possible to abandon costly, traumatic and inefficient manual work on felling, storage, burning, removal of wood and uprooting of stumps, which ultimately improves productivity and safety of work, especially at windfall and windbreak cutting areas. A number of researchers offer constructive solutions that allow combining the operations of soil milling or stump removal with planting seedlings and seedlings [1, 9, 10].

In connection with the foregoing, the following areas of application of milling tools can be distinguished: preparation for forest plantations; creation of firebreaks; maintenance of forest roads; crushing stumps; clearing the routes of oil and gas pipelines, power lines; clearing of right-of-way and slopes of roads and railways; maintenance of park roads; shredding old garden trees; soil preparation.

Mulchers and rotovators are made on self-propelled wheeled and tracked chassis (Figure 1) and mounted (Figures 2, 3) [5, 11].

In the self-propelled version, the power plant and all auxiliary systems are combined in one machine with front-mounted technological equipment.



Fig. 1. Self-propelled mulchers: a - PRINOTH AHWI RAPTOR 800 (Germany), b - AMKODOR FM30A1 (Republic of Belarus).



Fig. 2. Aggregation of mulchers AHWI M450m-1900 (a) and M550m-2410 (b) on the base chassis BELARUS-1221V.2 and the universal power tool UES-2-280A "PALESS 2U280A", respectively.

The main disadvantages of a self-propelled chassis, which are highly specialized, include: high initial cost, high specific fuel consumption, high maintenance and repair costs, which ultimately increases the cost of an hour of work. At the same time, the advantages of this design are high throughput and productivity. Self-propelled mulchers and rotators are effective in servicing linear objects or large areas where it is necessary to remove bushes, undergrowth, stumps and branches flush with the ground in one pass. With a small amount of work, the operation of self-propelled mulchers and a rotator at logging enterprises will be

inefficient from an economic point of view (high book value and cost of machine-shift operation). In this case, it is more expedient to use milling implements aggregated with agricultural or forestry tractors.

As for mulchers, a widespread version of the design is its hanging (Figure 3) on an excavator chassis manipulator with its own hydraulic system, or a rear mounted system with a separate hydraulic system, which allows you to clear the area from grass, shrubs and small trees in hard-to-reach places (shoulders and slopes). This arrangement implements the principle of modular machine systems, which provides for the possibility of equipping the base tractor with various technological equipment. At the same time, mounted mulchers have lower cost and performance.



Fig. 3. Mulchers mounted on the boom of an excavator and a manipulator of a wheeled tractor.

Mounted and self-propelled milling tools can be divided according to the type of drive of the working body: mechanical and hydraulic. The actuator with a mechanical drive (from the PTO), as a rule, is attached to the three-point hitch of the tractor, and sometimes they have their own adapted design. Such designs have power from 40 to 400 hp. and can be equipped with various options for rotors and cutting knives [6, 12, 13].

To drive the rotation of the rotor on powerful milling tools, a two-sided rotor drive is used, the transfer of force to which can be carried out through an integrated transfer case, elastic belts or side cardan shafts. To increase productivity and work efficiency, the implements are equipped with a pusher frame for pushing bushes and felling trees, rigidly fixed or hydraulically controlled. The height of the rotor position above the ground is determined by the installation of road wheels or adjustable skids.

The main working body in such machines is a rotating shaft-rotor fixed at the ends, the design of which is determined by the purpose, the material being processed and the working conditions. The rotor can be equipped with movable (hinged) hammers that chop wood due to impact (Figure 4), or fixed, rigidly fixed cutters with carbide inserts that chop wood by cutting [3, 11, 14, 15].



Fig. 4. Movable (a) and rigidly fixed (b) knives (hammers).

Often the manufacturer provides for each rotor several types of knives or hammers for grinding various materials: grass and branches knives or hammers for thick branches and stones.

To protect against scattering of chips, curtains made of metal plates, chains or rubber are used.

The main performance characteristics of the rotor are the working width and the diameter of the rotor. With an increase in the width of the rotor, the productivity of work increases, but at the same time the power consumption and weight of the milling tool increase, respectively, a more powerful carrier is required. In turn, the diameter of the rotor determines the height or depth of processing.

Some models of rotors are designed specifically to work with immersion in the ground, which allows you to crush roots and stumps, loosening the soil (installed on rotovators). Rotovators (Figure 5), designed to work with powerful energy carriers, are able to process areas with stumps up to 40 cm in diameter and sink into the ground up to 50 cm, providing deep soil cultivation. In this case, a large diameter rotor (1000 mm.), Rotating at a low speed, is used. As a rule, a pressure roller with a hydraulic lift is installed on the beam of this technological equipment [4, 5, 6].



Fig. 5. Rotators Seppi M StarSoil (a) and PRINOTH AHWI RF1000.

For grinding tree and shrub vegetation, in addition to rotary and disk grinding technologies, they are used. The main working body of machines operating on disk technology (Rotary Disc Mulching (RDM) Technology) is a disk milling cutter (Figure 6) with hard-alloy teeth fixed on it [2, 10].



Fig. 6. Disc Mounted Chopper.

Such cutters are usually mounted on the boom of an excavator or tractor. The disk cutters are driven by a hydraulic motor connected to the carrier's hydraulic system. With a low cost and small overall and mass parameters, this equipment has a number of disadvantages that

limit their intensive implementation, these include: a small width of capture (working width), the need for frequent change of teeth when working on the soil surface and low productivity.

Manufacturers from Western Europe, such as the Italian Seppi M, Ferri, FAE Group, Delta, Orsi Group, Agrimaster, the Spanish TMC Cancela, NIUBO, the French Galotrax, powerful shredders for work in the forest of the German company Prinoth (formerly AHWI) play a leading role in the mulcher market in the CIS countries. Considerable attention is paid to the creation of this equipment in the USA and Canada, where their leading manufacturers are Bandit, FMI (USA), Hakmet (Canada), Nokamic (Canada), Gyro-Trac (USA) and others. mounted mulchers at OAO Mogilevliftmash, UCHPP Stroyremavto, OOO Zavod Kommunalnaya Tekhnika. Ammak-Bel also implemented a number of projects for the introduction of self-propelled milling tools and the aggregation of attachments on various types of chassis manufactured in the Republic of Belarus. Among the considered designs of mounted and self-propelled mulchers, about 80% are mounted with different working widths [1, 3, 4, 5, 6].

3 Results and discussion

The conducted studies have shown that at present, machines and equipment for the removal of trees and shrubs are becoming more and more widespread. At the same time, there are a significant number of layout solutions that are based both on the use of specialized wheeled and tracked chassis, and on the use of agricultural and road-building machines as an energy source, which allows expanding their functionality and reducing operating costs. It should be noted that the widespread use of mulchers is due to their use in shredding trees and shrubs located above the soil level, as well as the possibility of their shredding with immersion in the ground. At the same time, effective tillage with this equipment is possible to a depth of 5–7 cm, which in some cases is sufficient. This concerns the care of power lines, gas and oil pipelines, the creation of mineralized strips. To grind the root part to a depth of up to 50 cm, rotovators are used, requiring the use of an energy vehicle of greater power [1, 2, 3, 16, 17, 18].

4 Conclusion

In recent years, milling tools (mulchers and rotary heads) have been actively introduced into the forestry, energy, road, oil and gas sectors, which ensure the effective performance of work related to the removal of trees and shrubs. Moreover, the active acquisition of this equipment was carried out by enterprises of the Ministry of Energy, as well as enterprises that care for gas and oil pipelines, and railways. In recent years, this equipment has been actively purchased by forestry institutions.

This equipment is aggregated on its own chassis or mass-produced energy carriers of various configurations. The main and most technologically complex element is its rotor with movable or fixed knives or hammers, which each manufacturer has its own original design, often protected by patents.

The predominant distribution on milling tools has received a two-way rotor drive, carried out through a stationary transfer case, high-performance elastic belts and side cardan shafts with optional torque. Due to the prevailing volume of work associated with chipping wood and the need to remove stumps, drum-type rotors with fixed carbide-toothed hammers of the UPT and UPTs types are used.

The review of the market for milling tools for chopping trees and shrubs gives reason to believe that, in order to ensure competitive and consumer properties, the produced mulchers and rotators have a wide range of technical characteristics, various options for aggregation

and drive, which makes it possible to select the necessary model based on operating conditions, the available fleet of energy carriers, and the need to solve specific problems. It should be noted that more than 95% of all milling tools are operated on a wheeled chassis and about 90% are driven by a PTO, which is due to high mobility and the possibility of realizing the maximum efficiency of the working body drive.

Milling tools are a popular product, and therefore today there are more than three dozen manufacturers in Western Europe, North America and the CIS.

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