Comparative characteristics of undercarriage systems as criteria for selecting a power tool for risky farming zones

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Abstract. The basis of modern machine and tractor fleet of industrial and agricultural tractors are power vehicles with caterpillar and wheeled undercarriage systems of various design. The article considers the summary parametric and factorial characteristics of wheeled and tracked power vehicles used in field and transport works under the conditions of the Amur region. The criteria of formation of their traction and traction properties are analysed, the ways of slipping reduction, reduction of vertical load of machine-tractor unit on the soil and application of agricultural machinery in the period of overwatering are given. The results of research on the application of mobile energy means in conditions of overwatering in the cultivation of agricultural crops, where their main advantages and disadvantages are reflected, the directions of choice of energy means for application in agricultural production technologies in conditions of weak bearing capacity of soils are substantiated. It is established that the use of tracked energy means having high traction and traction properties, when they are aggregated with wide-catch machines in the fields of the region, will be more effective in the periods of work, when there is a significant precipitation. At the same time, wheeled energy means will also be in demand in the natural-climatic conditions of the Amur region as the most universal means, structurally suitable for performing the majority of agricultural field operations as a part of tractor-transport aggregate. In this regard, the expediency of equipping the production-industrial complex and means of mechanisation of farms and agricultural enterprises of the region with power vehicles with different undercarriage systems in accordance with the used and scientifically substantiated regional system of machines and technologies is substantiated.

1 Introduction

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these and other power vehicles have their own advantages and quite significant disadvantages. In this connection, purchasing a tractor (caterpillar or wheeled), first of all it is necessary to decide, for direct performance of what tasks it is intended, taking into account such important factors as versatility in technologies, convenience of functions performance by the operator and his informativeness about technological parameters, repairability in repair and maintenance, regional adaptation to operating conditions and possibility of production modernisation, optimal cost of the equipment at the ratio "cost" and some others of which the most important in modern conditions is low cost, maximum localisation of production and certification on the territory of the Russian Federation [1-10].

2 Materials and methods

Let us consider in more detail the necessary criteria, most often used in the selection of the main undercarriage systems of tractors (Figure 1), optimally designed for regional agriculture, for which we will disclose in more detail the advantages and disadvantages of wheeled and tracked propulsion [1], in particular: 1). Economic factor - purchase price of the product and costs for maintenance of its operability; 2). Traction and cross-country ability; 3). Tractor-machine unit slippage and technogenic impact on the soil; 4). High manoeuvrability and small turning radius; 5). Convenience of travelling on paved roads.

Fig. 1. Basic crawler and wheeled undercarriage systems

2 Results and discussion

It is well known that the most important and responsibly significant factor in selecting a tractor undercarriage system is the economic factor that directly affects the price of the final product, namely the purchase price of the product and the costs of maintaining its performance. As a rule, the price range of wheeled and tracked power equipment differs considerably. The tracked undercarriage gear is much more expensive than the wheeled one, as it has a greater number of assemblies and parts, as well as additional elements in the design, has a greater labour intensity of repair and maintenance with a lower durability, in connection with which additional costs are required to engage specialists for repair and maintenance of the undercarriage gear, as well as the use of an additional range of sealing elements, oils and greases.

Thus, it can be concluded that repair and maintenance of the wheeled undercarriage gear of the energy vehicle will be less costly than the tracked one. In this connection, the wheeled...
The tractor will have more advantages by the criterion of acquisition, repair and maintenance costs, while being more reliable by the main criteria [3, 8].

Traction and cross-country ability. During traction works the undercarriage gear of a power tool (caterpillar or wheeled) transmits force to the driving surface, and the more intensive is the traction of the undercarriage gear with the soil-the more effective is the realization of power and traction qualities of the machine [4].

As it is known, an important criterion for the efficiency of caterpillar belts (Figure 2) is the area of the loaded surface, in connection with which the contact grip with the soil created by the drive and support elements of the caterpillar increases.

![Fig. 2. Rubber-metal caterpillars](image)

When using the crawler drive on soils of low moisture content, slippage is within 2-3%, which is a significant advantage over a wheeled tractor of the same power. The picture of the crawler drive looks worse in wet conditions, when the caterpillar track has no possibility to grip the wet topsoil, and there is slippage with burrowing of the machine up to its complete stop.

At the same time wheeled energy means have other peculiarities: so, in a tractor with wheels of the same diameter thrusters move one after another along one track, in connection with what losses on overcoming rolling resistance of the rear pair of wheels are reduced, but at the same time soil compaction increases. It has been noted that the track-to-track principle reduces the coefficient of soil resistance to movement, as slippage is reduced.

Standard tracked power vehicles have a slip rate of approximately 15% during traction operations. Consequently, for every 1,000 hours of arable work with constant slipping, 150 hours of slipping losses are incurred. A graph of wheeled and crawler tractor towing is shown in Figure 3.

![Fig. 3](image)
The results show an increase in tractive effort of the tractor with crawler undercarriage in contrast to the wheeled tractor. Thus, the increase in the contact patch of the undercarriage of the propulsion system with contributes to the efficient and point application of the power tool when performing labour-intensive tasks, such as basic tillage and sowing with combined aggregates, deep loosening and chiselling of the soil.

3 Slipping of the machine and tractor unit

When using machine-tractor aggregates with high weight and high-power characteristics, a crawler tractor can work with minimum slip within 3-6%, while a wheeled power tool can tow MTA of the same weight parameters, applying high power with increased slip of 15-40% [3, 10].

4 Reduction of load on the soil

As studies of authors [2, 5, 8] show, neither of the two undercarriage systems provides significant advantages in solving the problem of reducing the pressure of undercarriage systems on the soil (Figure 4). Positions A (wheeled tractor) and B (tracked tractor). The adopted designations obtained by instrumented strain gauge methods are:

1, 3, 5, 5, 7, 9, 11 - soil pressure pulses.
2. Assumed pressure on the soil from the wheels of the power tool.
4. Actual pressure on the soil from the wheels of the energy vehicle.
6. Actual ground pressure from the wheels of the energy vehicle.
Fig. 4. Pressure of wheel and crawler tracks on the ground

Pressure of wheel and crawler tracks on the ground Position A. When a properly balanced wheeled tractor with large radial tyres inflated with air (in accordance with the instructions) impacts the ground, the measured ground pressure does not increase significantly. This is because the tyres change their original geometry, expanding and elongating on the ground surface under load, thus increasing the contact area of the tractor's thrusters with the driving surface.

A very different picture is observed with a tracked power vehicle (Figure B).

8. Estimated soil pressure from the tracked power tool (static soil pressure is: weight of the tracked propulsion system divided by the total area of contact between the tracks and the soil).

10. Actual ground pressure from the crawler power unit.

12. Actual ground pressure from the tracked power vehicle.

Statement B. It has been proven that the ground pressure of the tracked power unit remains unchanged is incorrect, the crawler track does not equalise the vertical load on the propulsion contact strip. In fact, each support wheel above the crawler belt of the tractor slightly, but has a different value of pressure on the soil.

In the course of analysis of authors' works aimed at research of tractor pressure on soil, conducted in the state of Ohio, USA, when the process of influence of wheels of power vehicles on such physical parameters of soil as index of accretion, density, porosity, air permeability was studied, the data were obtained that properly balanced tractor with properly inflated tyres (to the required low pressure in accordance with the load on the axle) have the least pressure on soil. The second most effective of this indicator was the tracked power tool [7].

High manoeuvrability and small turning radius. The ability to control the power tool during tractor turning is the most important factor, the increase of which leads to a decrease in the productivity of MTA due to dislocation of working bodies or disconnection of trailed machine drives [5, 6, 9].

Comparatively, the crawler tractor will be more manoeuvrable in contrast to the wheeled power tool, as the crawler belts can be operated separately from each other and in different directions.
5 Convenience of travelling on paved roads for general purpose

As a rule, in various climatic conditions of the Amur Region, tractors quite often have to go to work sites and return to the park on asphalt roads. Despite the fact that tracked power vehicles are equipped with rubber and rubber-metal joints, wheeled power vehicles can reach higher speeds and have better softness of undercarriage on paved roads for general purpose from which it can be concluded that the criterion of travelling on paved roads is controversial to identify a clear leader of a particular propulsion system.

6 Conclusions

Summarising the conclusions of the conducted research, it is difficult to say precisely which undercarriage system will be suitable for the conditions of regional use. However, the use of tracked power vehicles with high traction and traction qualities, when combined with wide-catchment machines in the fields of the region, will be more effective when used in the period with high precipitation, as well as in the spring when carrying out field work, preparatory and sowing activities.

The wheeled power tool can be considered more suitable for the majority of agricultural field operations due to its versatility, as well as to be used as part of a tractor-transport aggregate.

At the same time, in order to reduce costs and increase productivity in the performance of basic agricultural operations for the cultivation of large area fields, it is advisable to equip the production complex of farms and enterprises of the region with different types of energy means in accordance with the adopted and used regional system of machines and technologies.

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