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AN OVERVIEW OF MODERN UNMANNED FOREST PLANTING MACHINES FOR PLANTING SEEDLINGS WITH A CLOSED ROOT SYSTEM

ОБЗОР СОВРЕМЕННЫХ БЕСПИЛОТНЫХ ЛЕСОПОСАДОЧНЫХ МАШИН ДЛЯ ПОСАДКИ САЖЕНЦЕВ С ЗАКРЫТОЙ КОРНЕВОЙ СИСТЕМОЙ

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Abstract: Forest planting machines are technical means designed to create planting sites, feed planted plants and embed their root system in the soil. These machines play an important role in the process of artificial reforestation, ensuring high labor productivity and reducing specific energy consumption when carrying out work on planting seedlings and seedlings of various species in modern conditions, the development of structures of forest planting machines Abroad, it demonstrates a tendency to create more efficient and versatile solutions that can be adapted for use in different climatic zones and soil types. Examples of such machines are the MLP-1 model with a cross-beam planting device designed for planting conifers in deforestation, as well as the universal machine MDL-1A, capable of working with seedlings and seedlings with an open root system in various areas, special attention is paid to improving the operational characteristics of forest plantations.

Keywords: unmanned vehicles, planting seedlings, autonomy, energy efficiency.

Аннотация: Лесопосадочные машины - это технические средства, предназначенные для создания посадочных площадок, подкормки высаженных растений и заделки их корневой системы в почву. Эти машины играют важную роль в процессе искусственного лесовосстановления, обеспечивая высокую производительность труда и снижая удельные энергозатраты при проведении работ по посадке сеянцев и саженцев различных пород в современных условиях, развитие конструкций лесопосадочных машин за рубежом демонстрирует тенденцию к созданию более эффективных и универсальных решения, которые могут быть адаптированы для использования в различных климатических зонах и типах почв. Примерами таких машин являются модель MLP-1 с поперечным посадочным устройством, предназначенная для посадки хвойных деревьев при вырубке леса, а также универсальная машина MDL-1A, способная работать с саженцами и рассадой с открытой корневой системой на

различных участках, при этом особое внимание уделяется улучшению эксплуатационных характеристик. характеристика лесных насаждений.

Ключевые слова: беспилотный летательный аппарат, посадка растений, энергоэффективность

Modern achievements in the field of unmanned technologies open up new horizons for the development of automatic seedling planting systems. Unmanned ground vehicles (UVs) designed for these purposes are becoming increasingly functional, which makes it possible to significantly increase the efficiency of reforestation and agricultural work. Let's consider the main promising areas of development of this technology [1].

The technological development of unmanned ground vehicles for planting seedlings with a closed root system follows several key directions, each of which is aimed at increasing the efficiency, autonomy and versatility of these systems. Let's consider the main aspects of development [2]:

1. Creating autonomy

Increasing the level of autonomy is one of the main trends in the development of unmanned vehicles. Improvements in artificial intelligence (AI) algorithms and navigation systems such as GPS and GLONASS allow machines to make more complex decisions without human intervention. For example, it can analyze the soil and the environment, determining the optimal location of each seedling and the depth of its planting, which helps to increase plant survival [3].

2. Introduction of new materials

The use of new structural materials such as composites and carbon fiber is becoming an important factor in the development of unmanned vehicles. These materials make structures lighter, stronger, and less susceptible to external factors such as corrosion or mechanical wear. This is especially important for machines operating in forestry conditions [4].

3. Improvement of monitoring systems

The development of monitoring and feedback systems opens up new opportunities

for improving the quality of operation of unmanned vehicles. Modern sensors allow you to monitor the condition of the soil, weather conditions and the planting process in real time. The introduction of Internet of Things (IoT) technologies and cloud solutions gives operators access to machine operation data, which allows them to quickly adjust task performance parameters [5].

4. Integration with drones

The integration of unmanned ground vehicles with unmanned aerial vehicles (UAVs) is a promising development area. UAVs can perform a preliminary analysis of the territory, and ground vehicles carry out the actual planting of seedlings. This approach has already shown its effectiveness in protecting and maintaining the stability of forest seed plantations [6], [7].

5. Energy efficiency

Reducing energy consumption remains an important goal for developers of unmanned vehicles. This uses highly efficient engines, batteries, and renewable energy sources such as solar panels. This is especially important for performing long-term technological operations in remote areas where access to power grids is limited [8].

6. Unification of platforms

The creation of universal basic structures that can be adapted for various tasks helps to reduce the cost of production and maintenance of equipment. Universal platforms can be easily converted to perform landing operations [9].

Classification of types of unmanned ground landing vehicles:

1. Machines with landing heads

The most common type of machine, equipped with special planting heads for precise positioning of seedlings in prepared wells or furrows. They automate the boarding process, minimizing human involvement, shown in Figure 1.

Figure 1 – Forest planting machines with electronic planting heads

2. Self-propelled machines for planting seedlings

Fully autonomous or semi-autonomous devices capable of navigating terrain without direct operator control. These machines are often equipped with navigation and AI systems for real-time decision-making on Figure 2 presented by car model concepts for planting forest crops.

Figure 2 – unmanned ground vehicles for planting seedlings from the ZKS

3. Universal forest planting machines

Designs adaptable to different conditions and plant types. They can be used for planting seedlings with a closed root system, as well as for other reforestation tasks, shown in Figure 3.

Figure 3 – Universal leopard planting machine.

Conclusion

The prospects for the development of technologies for unmanned ground vehicles for landing aircraft are very extensive. The main directions include enhanced autonomy, which allows machines to perform tasks without constant human involvement, as well as the introduction of new materials such as composites and light alloys, which make structures more durable and energy efficient.

In addition, improved monitoring systems using sensors and IoT technologies help to monitor soil conditions, weather conditions, and the planting process itself in real time. Integration with drones opens up opportunities for preliminary exploration of the territory and optimization of ground vehicle routes. Increasing energy efficiency through the use of modern engines and batteries helps to increase the operating time of machines on a single charge. Finally, the unification of platforms makes it possible to create universal solutions that can be adapted to various tasks in forestry and agriculture.

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