Рис. 2. Загальний вигляд стрілчастих плоскоріжучих лап на серповидних стовбах культиватора КВАНТ-7

випробування культиватора в цьому господарстві довели його переваги перед аналогами. Ефективність використання культиватора досягається за рахунок точного регулювання обробітку ґрунту за глибиною та якісної підготовки поверхні ґрунту порівняно з аналогічними культиваторами вітчизняного та зарубіжного виробництва. Агрегатуються з тракторами тягового класу – 4 і забезпечує високу продуктивність 6,3–8,4 га/год при глибині обробітку 4–6 см.

Список використаних джерел

1. Адамчук В. В., Антонець С. С., Василенко М. О., Єранкін О. Н., Буслаєв Д. О. Культиватор КВАНТ–7 для передпосівного обробітку гранту в органічному землеробстві. Аграрна наука – виробництву. Київ, 2017. № 2. С. 26.

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ACHIEVING CLIMATE NEUTRALITY IN AGRICULTURAL MACHINERY ENGINEERING: STRATEGIC, TECHNOLOGICAL, AND INSTITUTIONAL DIMENSIONS FOR UKRAINE

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Global climate policy aimed at achieving carbon neutrality is redefining the development parameters of industry, particularly the machinery manufacturing sector. Agricultural machinery engineering occupies a distinctive position, as it combines resource-intensive production with the subsequent operation of equipment associated with significant greenhouse gas emissions. For Ukraine, the issue of sectoral climate neutrality is becoming strategically important in the context of European integration processes, the need for technological modernization, and the enhancement of competitiveness in international markets.

The carbon impact of agricultural machinery is generated throughout its entire life cycle – from raw material extraction and processing to end-of-life disposal. Metal production, energy-intensive manufacturing processes, the use of diesel fuel during operation, and the insufficient level of recycling of decommissioned machinery collectively form substantial environmental pressure. Therefore, climate neutrality in the sector implies not only the reduction of operational emissions but also systemic optimization of material, energy, and design parameters of machinery.

Current EU regulatory trends emphasize industrial decarbonization, product energy efficiency, circular economy development, and the implementation of eco-design principles. These requirements shape a new engineering design paradigm in which durability, reparability, modularity, and material recyclability become key attributes. For Ukrainian manufacturers, this represents both a challenge and an opportunity for integration into European production value chains.

Technical solutions play a decisive role in the decarbonization process. Reducing material intensity is achieved through the use of high-strength alloys, geometric optimization of components, and the application of additive manufacturing technologies. Improvements in machine energy efficiency are associated with advanced drive systems, reduced mechanical losses, and the implementation of hybrid or electrified systems. An important direction is machinery design based on circularity principles, including component standardization, ease of disassembly, and reuse of parts.

The transition to climate neutrality is interstage in nature and based on the interconnection of technical, economic, and environmental parameters. Each emission source is considered an object of engineering intervention, while design modifications simultaneously ensure resource conservation, economic efficiency, and reduction of the overall carbon burden. Thus, environmental requirements become integrated into the logic of engineering design and serve as a driver of technological modernization (Table 1).

1. Systematization of Transition Pathways

Life Cycle Stage	Impact Points	Priority Engineering Solutions	Economic Effect	Environmental Outcome
Materials	Carbon-intensive production of metals and polymers	Lightweight and high-strength materials, secondary raw materials, structural optimization	Reduced material and transportation costs	Lower primary emissions
Manufacturing	High energy consumption of technological processes	Energy-efficient equipment, digitalization, additive technologies	Lower production costs	Reduced industrial emissions

Design	Excess mass, energy losses	Transmission optimization, electrification of components	Lower fuel consumption	Reduced operational emissions
Operation	Use of fossil fuels	Precision agriculture, alternative fuels	Resource savings, higher productivity	Reduced agricultural carbon footprint
Maintenance	Frequent replacements and waste generation	Modularity, reparability	Extended equipment service life	Reduced indirect emissions
End of Life	Disposal without recycling	Disassemblable structures, material recycling	Recovery of secondary raw materials	Reduced overall environmental impact

Environmentally oriented innovations contribute to lower operating costs, provide access to new markets, and generate demand for service-based and remanufacturing business models. At the same time, the success of the transformation depends on the advancement of research, the training of specialists with competencies in eco-design, and the integration of sustainable development principles into engineering education.

Achieving climate neutrality in Ukraine's agricultural machinery engineering is a multidimensional process combining technological innovation, economic feasibility, and EU regulatory guidance. Engineering design serves as a key instrument of decarbonization, while a life-cycle-based systemic approach ensures reduced environmental impact and improved sectoral competitiveness.

References

1. Bumbiere, K., Meikulane, E., Gravelsins, A., Pubule, J., & Blumberga, D. (2023). Progress of the agricultural sector toward climate neutrality: Identification of essential stages. *Sustainability*, *15*(14), 11136. https://doi.org/10.3390/su151411136

2. Ma, W., Yang, X., & Tian, Z. (2024). Agriculture neutralization: Perspective from intelligent agricultural machinery. *Circular Agricultural Systems, 1–5*. https://doi.org/10.48130/cas-0024-0002

3. Van Hoof, S. (2023). Climate change mitigation in agriculture: Barriers to the adoption of carbon farming policies in the EU. *Sustainability, 15*(13), 10452. https://doi.org/10.3390/su151310452

4. Progress and prospects for decarbonisation in the agriculture sector and beyond. *European Environment Agency (EEA)*. https://www.eea.europa.eu/en/analysis/publications/progress-and-prospects-for-decarbonisation-in-the-agriculture-sector-and-beyond

5. Zhuang, M., Wang, X., Yang, Y., Wu, Y., Wang, L., & Lu, X. (2025). Agricultural machinery could contribute 20% of total carbon and air pollutant