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ПРИМЕНЕНИЕ ИОНИСТОРОВ В СЕЛЬСКОМ ХОЗЯЙСТВЕ

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Аннотация. Настоящая статья посвящена анализу потенциала использования ионисторов (суперконденсаторов) в агропромышленном комплексе. В статье рассматривается сущность, преимущества использования ионисторов и основные области их применения в агропромышленном комплексе Республики Беларусь.

APPLICATION OF SUPERCAPACITORS IN AGRICULTURE

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The agricultural sector faces a growing demand for improving operational efficiency while simultaneously reducing operating costs, primarily through fuel savings. Traditional power systems of agricultural machinery (tractors, harvesters) often operate in cyclic modes with high peak loads (for example, when activating heavy-mounted equipment or during rapid acceleration), leading to inefficient fuel combustion and increased engine wear. [1]

The solution to this problem lies in hybridizing power systems and employing highly efficient energy storage devices. Among promising technologies, supercapacitors stand out for their high power density and extremely long service life, making them ideal for compensating for short-term but substantial power fluctuations.

Supercapacitors are electrochemical energy storage devices that operate on the accumulation of charge in a double electric layer at the interface between the electrode and the electrolyte (see Fig. 1). [4]

Unlike lithium-ion batteries, supercapacitors have a lower energy density but a much higher power capacity, which allows them to:

1. Rapidly deliver and absorb charge (regeneration): this feature is critically important for heavy agricultural machinery, where the kinetic energy generated during braking or during the lowering and lifting of mounted implements can be efficiently converted into electrical energy and stored.

2. Stand millions of charge/discharge cycles: it ensures system durability exceeding the service life of the equipment.

3. Retain the charge during a long period of time: it allows equipment to be used after a long period of station downtime.

4. Discharge completely without damaging the device: it prevents degradation of materials it is made of. [2]

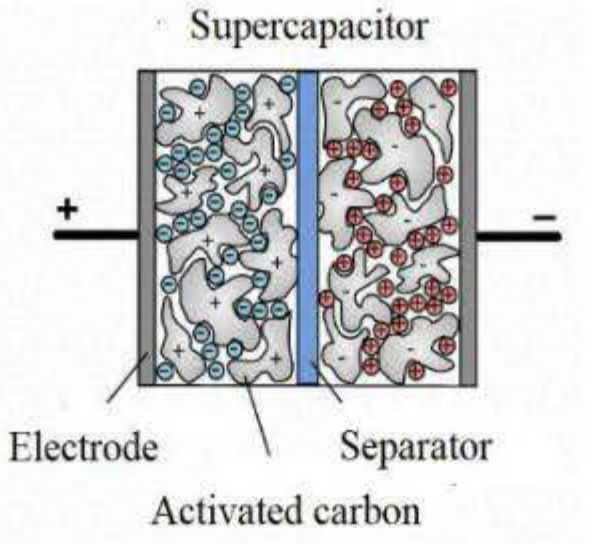

Figure 1 – Structure of a supercapacitor

A comparison of key characteristics of storage devices is presented in Table 1.

Table 1. Comparison of key characteristics of energy storage systems for hybrid applications

Characteristic	Lead-acid battery	Lithium-ion battery	Supercapacitor
Power density	Low	Medium	High
Service life (cycles)	500 – 1 000	2 000 – 5 000	1 000 000+
Charging time	Hours	Hours	Seconds/Minutes

Judging by key characteristics, supercapacitors have the best results. So they can be recommended for usage in agricultural electrical equipment. The use of supercapacitors in the agro-industrial complex of the Republic of Belarus can be divided into three key areas:

1. Hybrid power units: Supercapacitors are installed in parallel with the main power source (engine + generator or battery) and provide instant power boosts. This allows the use of a less powerful main engine operating in its optimal mode, while peak demands are met by the energy stored in the supercapacitor.

2. Electrification of mounted equipment: The use of supercapacitors to power electric drives of seeders, sprayers, and cultivators that require short-term high power (see Fig. 2).

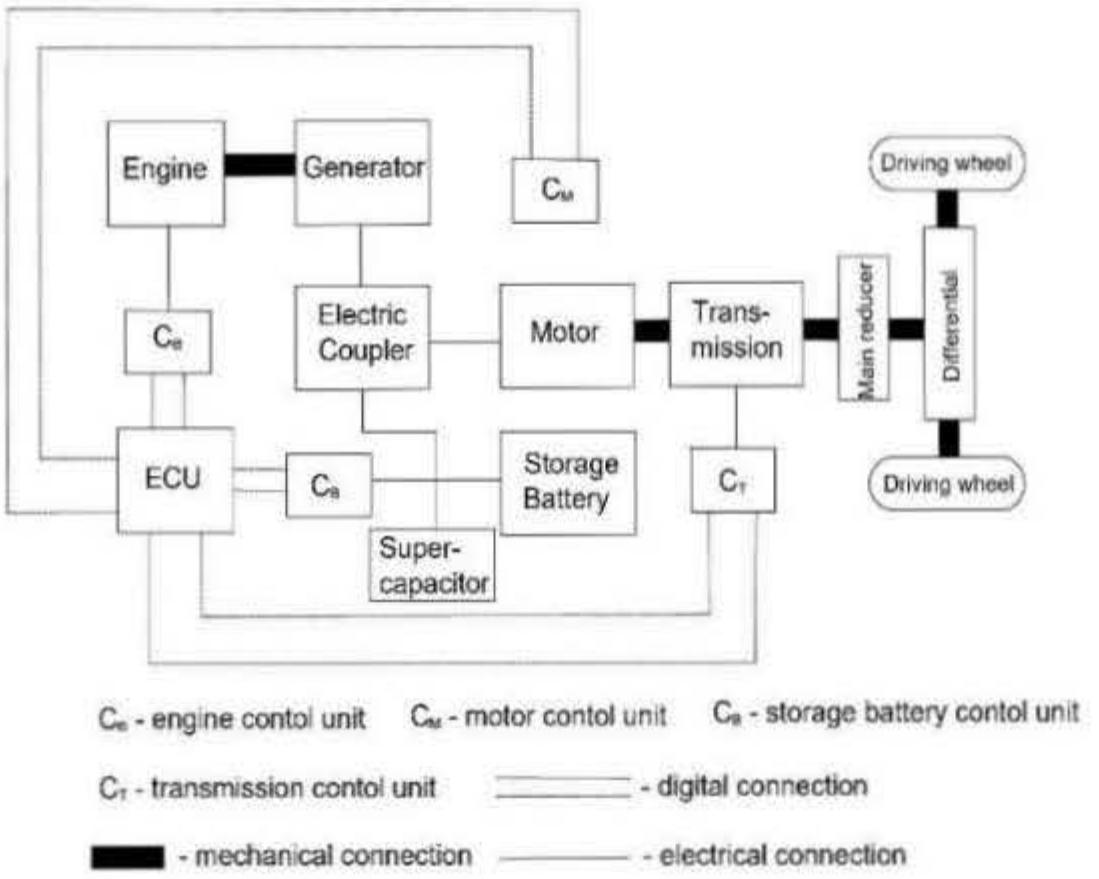

Figure 2 – Structural diagram of the supercapacitor system

3. Autonomous systems: Power supply for onboard systems, monitoring sensors, and unmanned aerial vehicles used for agro-monitoring, where the key advantage is the ability for rapid recharging in field conditions.

In conclusion, it should be noted that the integration of supercapacitors into hybrid power systems of agricultural machinery is an effective technical solution that helps address the issue of inefficient energy use under cyclic and peak loads. It has been proven that the average fuel consumption can be reduced by 10–15% through energy recuperation and optimization of the main engine's operating mode. A significant increase in the service life of traditional battery systems in hybrid configurations has been confirmed.

Список литературы

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