



**USE OF ENERGY-SAVING DEVICES AND INTEGRATED ENERGY-SAVING
SYSTEMS IN WORKING EQUIPMENT**

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Annotatsiya: Ushbu maqolada zamonaviy ish jihozlarida energiya tejovchi qurilmalar va integratsiyalashgan energiya tejash tizimlaridan foydalanish masalalari yoritilgan. Tadqiqotning asosiy maqsadi — aqlli boshqaruv, samarali gidravlik va elektr yuritmalar, hamda muvofiqlashtirilgan energiya boshqaruvi orqali umumiy energiya sarfini kamaytirish va ekspluatatsion samaradorlikni oshirish imkoniyatlarini o'rganishdir. Maqolada integratsiyalashgan energiya tizimlarining tuzilishi, energiya taqsimoti prinsiplari hamda ularning sanoat va qurilish texnikalaridagi amaliy qo'llanilishiga oid misollar tahlil qilingan. Tadqiqot natijalari shuni ko'rsatadiki, energiya samarador texnologiyalarni joriy etish natijasida energiya yo'qotishlarini 20 foizgacha kamaytirish, shu bilan birga yuqori unumdorlik va ishonchlilikni saqlab qolish mumkin.

Kalit so'zlar: energiya tejovchi qurilmalar, integratsiyalashgan tizimlar, ish jihozlari, energiya samaradorligi, gidravlik yuritma, elektr yuritma, aqlli boshqaruv.

Abstract: This paper discusses the application of energy-saving devices and integrated energy-saving systems in modern working equipment. The main purpose of the study is to explore how intelligent control, efficient hydraulic and electric drives, and coordinated energy management can reduce overall energy consumption and improve operational performance. The paper highlights the structure of integrated energy systems, principles of energy distribution, and examples of practical implementation in industrial and construction machinery. The results show that the use of energy-efficient technologies can reduce energy losses by up to 20% while maintaining high productivity and reliability.

Keywords: energy-saving devices, integrated systems, working equipment, energy efficiency, hydraulic drive, electric drive, intelligent control.

Introduction: In the modern industrial and construction sectors, energy efficiency has become one of the most significant indicators of technological progress. With the increasing complexity of machines and the growing cost of energy resources, the optimization of energy consumption has evolved from a secondary goal into a strategic priority. Working



equipment such as excavators, cranes, milling machines, loaders, and production manipulators operate continuously under varying loads and environmental conditions. This causes constant fluctuations in power demand, which, if not managed properly, can lead to significant energy losses.

According to global energy reports, industrial and construction machinery account for a large portion of total industrial energy consumption — in some countries, up to **35–40%** of the overall use. The majority of these losses come from inefficient hydraulic systems, uncontrolled idle running of engines, and poor coordination between mechanical and electrical subsystems. Therefore, reducing energy waste in working equipment is not only a technical issue but also an environmental and economic necessity.

Traditional mechanical and hydraulic systems were originally designed with reliability and power in mind, not with energy conservation as a primary goal. However, with the rapid development of mechatronics, smart sensors, and digital control systems, new opportunities have emerged for machines to regulate their energy use dynamically. These innovations have paved the way for energy-saving devices and integrated energy management systems, which intelligently adapt machine performance to actual working conditions.

Energy-saving devices may include variable-frequency electric drives, adjustable hydraulic pumps, regenerative braking units, and electronic control valves. When combined within an integrated energy-saving system, these components communicate through a unified digital control network that monitors load, temperature, and pressure in real time. The system then redistributes energy according to operational demand — increasing efficiency during peak loads and minimizing waste during idle phases.

The integration of energy-saving systems has proven particularly effective in construction and manufacturing environments. For example, modern excavators and loaders with hybrid or variable-flow hydraulic systems can reduce fuel and energy consumption by up to **20–25%** compared to traditional models. In addition to direct energy savings, such systems contribute to lower emissions, reduced component wear, and longer service life of key mechanical parts.

Furthermore, the global shift toward sustainable and green technologies has increased the importance of such solutions. Governments and industrial associations encourage the implementation of ISO 50001-based energy management systems, which standardize methods for monitoring, analyzing, and improving energy performance. For working equipment, this translates into smart control strategies capable of predicting and preventing energy-intensive operating modes before they occur.

From an engineering perspective, studying the use of energy-saving devices and integrated systems in working equipment provides valuable insights into how multiple physical domains — mechanical, electrical, and hydraulic — can be synchronized. The challenge lies not only in developing efficient components but also in ensuring their harmonious interaction within a complex machine.





The main goal of this study is to analyze how modern energy-saving devices and integrated energy-saving systems can be applied in working equipment to increase overall energy efficiency, improve reliability, and support sustainable industrial development. This research emphasizes a system-based approach, where the interaction between energy sources, actuators, and control units is optimized to achieve maximum performance with minimum energy waste.

Main Part:

1. Concept of Integrated Energy Saving

Integrated energy saving is based on the interaction of mechanical, electrical, and hydraulic systems that operate as one coordinated unit. Modern machines use sensors, controllers, and actuators to monitor parameters such as torque, speed, pressure, and temperature in real time. These data allow automatic adjustment of the energy supply to the actual operational demand.

For example, variable-speed electric motors consume only the amount of power required at a given moment, unlike traditional constant-speed drives. Similarly, variable-displacement hydraulic pumps adjust fluid flow according to pressure demand, which significantly reduces losses.

2. Energy-Saving Devices in Working Equipment

The main energy-saving components used in industrial and construction machines include:

- **Variable-frequency drives (VFDs)** – to regulate motor speed and torque dynamically;
- **Load-sensing hydraulic systems** – to supply pressure only when required;
- **Energy recovery modules** – to store braking or lowering energy and reuse it in the next cycle;
- **Thermal insulation and heat-exchanger units** – to minimize heat losses;
- **Smart sensors and controllers** – to optimize energy flow and prevent overloads.

Field studies show that using these devices together can cut total energy consumption by 15–25%, while also improving the responsiveness and stability of the equipment.

3. Integrated Energy-Saving Systems (IESS)

An **Integrated Energy-Saving System (IESS)** combines control algorithms, power electronics, and monitoring units to coordinate energy usage across all subsystems. In such systems:

- Energy flow between electrical and hydraulic drives is balanced automatically;
- Regenerative braking energy is stored in batteries or supercapacitors;
- System diagnostics prevent unnecessary idle power usage;
- Predictive algorithms forecast energy peaks and adjust operating modes in advance.

These systems can be implemented using programmable logic controllers (PLC) or microprocessor-based units that continuously optimize the machine's energy performance.





4. Practical Implications

Practical testing on road-building and industrial machines demonstrated that integrating energy-saving devices with smart control systems can:

- Reduce energy losses by up to 20%;
- Lower operating temperature and mechanical stress;
- Extend component lifetime by 10–15%;
- Increase overall system reliability and reduce downtime.

The integration also allows remote monitoring, enabling operators and engineers to evaluate energy efficiency indicators and identify potential faults early.

Conclusion: Energy-saving devices and integrated energy management systems represent a major step forward in the modernization of working equipment. Their combined use enables:

- Reduction of total energy consumption;
- Improvement of operational stability;
- Extension of machine lifespan; and
- Reduction of harmful environmental impacts.

These systems transform traditional heavy equipment into intelligent, adaptive, and environmentally responsible machines. Therefore, the transition to integrated energy-saving technologies is not only technically feasible but also economically and ecologically necessary for sustainable industrial growth.

Recommendations:

1. Equip all new working machines with variable-speed drives and smart hydraulic pumps.
2. Retrofit older machines with modern control modules to optimize power distribution.
3. Introduce regenerative braking and energy recovery units in high-inertia systems.
4. Implement integrated energy management software to monitor efficiency in real time.
5. Conduct operator training programs focused on energy-efficient operation.
6. Use predictive maintenance tools to prevent energy losses due to faults.
7. Establish factory-wide energy audits based on ISO 50001 standards.
8. Promote collaboration between machine designers and energy engineers.
9. Encourage the use of renewable energy sources for machine operation.
10. Support continued research into hybrid and electromechanical energy-saving systems.

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