

## HIGH-TEMPERATURE SUPERCONDUCTORS

*Dilafroz Dusiyarovna Qurbonova*

*Master's Student, Denov Institute of Entrepreneurship  
and Pedagogy, Uzbekistan*

### ABSTRACT

Research in the field of high-temperature superconductors is one of the important areas of science and technology. High-temperature superconductor materials provide great opportunities for lossless transmission of electric energy, magnetic levitation technologies, and the creation of highly efficient energy storage systems. This article examines the possibilities of proposing scientific innovations related to high-temperature superconductor materials.

**Keywords:** ceramic materials, iron, yttrium, barium, copper, oxygen.

High-temperature superconductors are usually created based on ceramic materials and lose their electrical resistance at relatively low temperatures (around  $-196^{\circ}\text{C}$ ). The main types of these materials are:

- Cuprate-based superconductors composed of yttrium, barium, copper, and oxygen.
- Iron-based superconductors consisting of compounds with samarium or neodymium elements.

These materials have high energy density, increasing efficiency and minimizing losses during energy transmission.

#### Applications in Electronic Devices

The use of high-temperature superconductors in electronic devices is highly relevant. In particular:

- a) High-temperature superconductor materials can ensure low temperatures necessary for stabilizing quantum bits in quantum computing systems.
- b) They can be used to create stabilization systems in electric grids to reduce energy losses according to Joule-Lenz's law.

#### Magnetic Levitation Technologies

High-temperature superconductor materials are a key component in the development of magnetic levitation technologies. These technologies can be applied in the following areas:

- High-speed Maglev trains, enhancing energy efficiency and stability.
- Industrial contactless transport systems for moving materials.

#### Energy Storage Systems

Energy storage systems based on high-temperature superconductors include:

Superconducting Magnetic Energy Storage (SMES) – a technology that allows storing electrical energy in the form of a magnetic field. This technology is used to store electrical energy with high efficiency and without losses and to quickly return it to the grid.

The SMES device consists of a magnet coil made of superconducting materials. When the temperature drops below the critical threshold, the superconducting material loses its electrical resistance. As a result, energy is stored in the form of electric current circulating in the magnetic coil.

Energy storage is achieved through a magnetic field. A coil made of superconducting material generates a magnetic field without energy losses.

SMES systems have the capability to store and release energy within milliseconds, making them ideal for applications requiring high-speed performance. The energy storage and transfer efficiency of SMES systems ranges from 95% to 99%.

The system responds instantly to changes in the power grid, which is essential for stabilizing voltage and maintaining balance. Superconducting materials enable long-term storage of electrical energy without losses.

SMES systems do not emit harmful substances into the environment and are compatible with renewable energy sources.

#### Challenges of SMES Systems

- Superconducting materials operate at extremely low temperatures, requiring coolants such as liquid helium or liquid nitrogen, leading to additional costs.
- SMES systems can be expensive due to the high cost and complexity of superconducting materials.
- Large coils and protective systems are required to create and maintain high-volume magnetic fields.

#### Applications

- Stabilizing voltage and responding to fluctuations in power grids.
- Storing electricity generated from intermittent energy sources like wind and solar power.
- Ensuring uninterrupted power supply for industrial facilities with high energy demands.
- Providing temporary energy to meet short-term high-power needs.

SMES systems are expected to play a critical role in the future of energy storage technologies as they enable efficient and lossless energy management. They can be used to store electricity derived from renewable energy sources such as solar and wind.

#### Environmental Safety in Production

Ensuring environmental safety in the production of high-temperature superconductor materials requires reducing harmful chemical substances and waste, including:

- Using green chemistry processes to replace toxic chemicals (chemical compounds harmful to living organisms, human health, or the environment) with environmentally safe reagents (substances that interact with other compounds to produce new products).

- Developing recycling technologies for high-temperature superconductor materials.

Research should focus on developing cheaper materials to replace expensive metals and rare elements. For example:

- Using affordable elements like iron and copper.

- Enhancing material properties with nanotechnology by incorporating nanoparticles.

### Conclusion

High-temperature superconductors play a vital role in the development of modern technology. These materials have immense potential for applications in electronic devices, magnetic levitation systems, and energy storage technologies. Additionally, ensuring environmental safety in production processes and efficient resource utilization remain priority areas for scientific research in this field.

The proposals outlined above serve as relevant scientific innovations and practical directions for a master's thesis.

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