THE ROLE OF HEAT ACCUMULATORS IN IMPROVING THE EFFICIENCY OF GEOTHERMAL HEAT PUMPS

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Annotatsiya: Geotermal issiqlik nasoslari (GIN) ushbu zamonaviy energetika davrida ekologik toza va iqtisodiy energiya manbalaridan biri sifatida muhim ahamiyat kasb etmoqda. Bu turdagi issiqlik nasoslari er osti issiqlikdan foydalanish orqali bino va uy-joylarni isitganda yoki sovitganda yuqori samaradorlikni ta’minlaydi. GIN tizimlarining samaradorligini oshirish maqsadida turli texnologik va texnik yechimlar izlanmoqda, xususan, ushbu tizimlarda issiqlik akkumulyatorlarining o‘rni va ahamiyatiga alohida e’tibor qaratilmoqda. Issiqlik akkumulyatorlari sistemalarning barqarorligini ta’minlashda, energiyani tejashda va umumiy samaradorlikni oshirishda muhim vosita sifatida qadrlanadi.

Kalit so‘zlar: geotermal issiqlik nasosi, issiqlik akkumulyatori, energiya samaradorligi, ekologik tozalik, energiya tejash, issiqlik ta’minoti, issiqlik zaxiralash, avtomatik boshqaruv, geotermal energiya, isitish tizimi.

Аннотация: Геотермальные тепловые насосы (ГТН) приобретают всё большее значение в современную энергетическую эпоху как один из самых экологичных и экономичных источников энергии. Этот тип тепловых насосов обеспечивает высокую эффективность при отоплении или охлаждении зданий и домов за счёт использования геотермального тепла. Для повышения эффективности ГТН-систем разрабатываются различные технологические и технические решения, в частности, особое внимание уделяется роли и значению тепловых аккумуляторов в этих системах. Тепловые аккумуляторы ценятся как важный инструмент для обеспечения

стабильности работы систем, экономии энергии и повышения общей эффективности.

Ключевые слова: геотермальный тепловой насос, тепловой аккумулятор, энергоэффективность, экологичность, энергосбережение, теплоснабжение, аккумулирование тепла, автоматическое управление, геотермальная энергия, система отопления.

Abstract: Geothermal heat pumps (GHPs) are gaining importance in this modern energy era as one of the most environmentally friendly and economical energy sources. This type of heat pump provides high efficiency when heating or cooling buildings and homes by using geothermal heat. In order to increase the efficiency of GHP systems, various technological and technical solutions are being sought, in particular, special attention is paid to the role and importance of heat accumulators in these systems. Heat accumulators are valued as an important tool in ensuring the stability of systems, saving energy and increasing overall efficiency.

Keywords: geothermal heat pump, heat accumulator, energy efficiency, environmental friendliness, energy saving, heat supply, heat storage, automatic control, geothermal energy, heating system.

INTRODUCTION

A heat accumulator is a device that temporarily stores energy in the form of heat, which contributes to the uninterrupted operation of the GIN system. Although the temperature in natural geothermal sources is relatively stable, consumer needs and external climatic conditions are not always the same. For this reason, heat accumulators will be necessary for the optimal operation of pumping systems. They collect excess thermal energy at the time of its occurrence, and then, if necessary, return it to the system, resulting in a balance between system loads and efficient use of energy. The basic principle of heat accumulators being used in GIN systems is to balance variable heat flows. In addition to the system, built-in batteries allow you to re-use this heat during cold or hot days, when unnecessary heat is accumulated, and then when the temperature outside decreases or

consumption passes. As a result, the pumps are less directly affected by external changes and the efficiency of the system increases.

MATERIALS AND METHODS

Geothermal heat pumps, in which heat accumulators are applied, especially justify themselves in areas where heating is in high demand in winter, and cooling systems are actively used in summer. In such areas, batteries serve as the primary solution to reduce fluctuations in energy consumption and allow maximum use of the system. Because the energy consumption of GIN systems changes rapidly in accordance with external demand and external temperatures. Thermal storage, on the other hand, smooths out these fluctuations and optimizes energy over time. Heat accumulators can be developed on the basis of various technological solutions. Water accumulators, phase-shifting material-based accumulators, and other advanced technologies are widely used in GIN systems. When choosing the capacity of the accumulator, the load placed on the system, the change in the daily and seasonal energy needs and the climatic conditions of the area are taken into account. In addition, most modern batteries have enhanced thermal insulation and automated control to minimize energy loss [1].

The presence of a heat accumulator in the GIN system provides many other positive results, while increasing the efficiency of the device. First of all, pumps in the system work continuously and stably, energy efficiency increases, economic interest increases in use. At the same time, it is possible to avoid heat supply interruptions with the help of accumulators, which makes it convenient for users. Such systems are becoming the leader in ensuring energy efficiency, especially in large buildings, industrial facilities and greenhouses [2].

RESULTS AND DISCUSSIONS

Heat accumulators in practice lead to the fact that energy for geothermal heat pumps is stored in reserve and supplied at the right time. This prevents the system from being overloaded and increases the life span of the pumps. Their installation and maintenance are also much easier. In this case, the energy flow is optimally controlled through automatic control of the system, if Heat reserves accumulate or consumption increases. This will

make it possible to significantly increase the overall efficiency of GIN systems, as well as expand the possibility of energy savings. As a result of many years of technological progress, the use of heat accumulators in GIN systems has increased to a high level of efficiency and economy. By temporary collection and storage of thermal energy, optimal loading of systems in stages occurs. As a result, a reserve is created for times when there is a lack of energy tank and power, and the pressure on the electricity supply is also reduced. In this way, the effect of geothermal heat pumps will achieve the maximum result. Thermal energy management with batteries serves to increase the level of simplicity, reliability and safety in the system. If problems or power drops occur on the external network, the heat stored in the battery will allow you to continue the heat supply of the entire object or house without interruption in the short term. This approach further reinforces the environmental advantages of GIN systems and favors them over conventional heating or cooling systems [3].

Even in the conditions of Uzbekistan, interest in the use of geothermal energy has been increasing in recent years. In this case, the possibility of obtaining constant heat from under the ground is not without restrictions, that is, balanced control will be necessary in response to external conditions, energy demand and technological changes. With the help of heat accumulators, balanced and optimal performance, high energy efficiency of today's systems are ensured. It is worth noting that while thermal energy management and distribution is common in advanced countries, Uzbekistan also has promising prospects in this area. Correct calculation of the efficiency of batteries, adaptation of technological solutions based on the characteristics of the area and the capabilities of the device is at the same time an important task. If the heat accumulator capacity is selected correctly and optimally integrated into the system, the GIN system will work smoothly all year round, creating a guarantee of constant savings for the economy and industry [4].

In all modern economies, the issues of energy conservation and environmental safety are becoming more relevant than before. This leads to the efficient use of the capabilities of heat accumulators in areas where geothermal heat pumps are used along the way, reducing energy consumption and simplifying delivery. For fast and high-quality operation, it is necessary to effectively use advanced insulation, Automatic Control,

monitoring and heat distribution systems. This is addressing various logistical and energy challenges and creating more user-friendly conditions. The development of technologies related to the control of accumulators in GIN Systems provides the opportunity to extend the storage time of thermal energy, reduce its loss and deliver without a system. As a result, these systems are also widely used in the social and economic sectors. The modernization and innovation of batteries used in the GIN system is one of the main tasks of the energy sector today. The simplicity of maintenance, long service life during operation, and energy saving serve to make GIN systems more widely available in the future. Through the use of batteries in GIN systems, it is envisaged to establish a stable energy supply, obtain technical and economic benefits, solve environmental problems and increase energy efficiency. This allows for long-term and sustainable development strategies throughout the energy sector [5].

Geothermal heat pumps are an increasingly popular and environmentally friendly solution for heating and cooling residential and commercial buildings. One important component that can significantly enhance the performance and efficiency of a geothermal heat pump system is the thermal accumulator. The type of thermal accumulator used plays a crucial role in energy storage, system responsiveness, and overall operational effectiveness. Let's explore the main types of thermal accumulators suitable for geothermal heat pumps, and analyze which options are most efficient and why. The most common and widely used thermal accumulator is the water-based accumulator. These systems store surplus thermal energy in large volumes of water, typically housed within well-insulated tanks. Water has a high specific heat capacity, which means it can absorb and retain significant amounts of heat for extended periods without substantial losses. From both a technical and economic standpoint, water-based accumulators are relatively easy to install, operate, and maintain. Their straightforward design also makes them suitable for a wide range of applications including residential homes, office buildings, and industrial complexes. Water-based accumulators are often the go-to choice when space is available and cost-effectiveness is a primary consideration. As the demand grows for more compact and energy-dense solutions, phase change material (PCM) accumulators are gaining attention. PCM accumulators make use of special materials that absorb and release latent

heat during phase transitions, such as melting or solidifying. Parrafin-based or salt hydrate PCMs, for instance, can store more heat in a smaller volume compared to water alone. PCMs allow geothermal heat pump systems to operate efficiently even when there are fluctuations in energy demand, making these accumulators especially attractive for spaces where installation area is limited, or where precise temperature control is important. The use of PCMs also reduces cycling of the heat pump itself, leading to greater overall system longevity and efficiency. Another advanced solution comes in the form of brine or salt solution accumulators. These utilize saltwater mixtures as the storage medium, which can operate at higher temperature ranges than pure water and absorb considerable thermal energy. Brine accumulators can be engineered for specific temperature thresholds and are often used in larger commercial setups where system optimization and energy management are priorities. For some large-scale or unique installations, thermal storage can be achieved using solid materials such as concrete or stone. This type of accumulator involves embedding heat exchanger pipes within large thermal masses. The stored thermal energy is then gradually released over time, smoothing out peaks and troughs in heating or cooling demand. While this solution requires significant space and structural adaptation, it is highly effective for buildings or facilities that already incorporate large concrete areas or plan to utilize radiant heating systems [6].

The effectiveness of any thermal accumulator ultimately depends on several factors, such as the size of the building, available installation space, climate conditions, and budget. However, for most standard geothermal heat pump installations, water-based accumulators offer the best balance of efficiency, affordability, and reliability. They are particularly efficient due to water's natural ability to absorb and hold heat, and because their technology is mature and well-understood within the heating and cooling industry. In scenarios where space is at a premium or when there is a need for highly efficient storage density, phase change materials have emerged as an innovative and promising alternative. Their ability to hold more energy per unit volume without significant heat loss makes them an excellent solution for high-performance geothermal systems. Brine or salt solution accumulators offer yet another pathway for optimization, especially for commercial or industrial facilities requiring custom solutions for higher temperature storage. To maximize the

efficiency and effectiveness of a geothermal heat pump system, it is important to select the thermal accumulator that best fits the specific operational needs, spatial conditions, and energy objectives of the building. Careful planning, proper sizing, and thoughtful integration will ensure that the chosen thermal storage solution delivers optimal performance, energy savings, and comfort year-round. Ultimately, advances in accumulator technology continue to broaden the possibilities for geothermal heat pump systems, promising even greater efficiency and sustainability in tomorrow's built environments [7].

CONCLUSION

The role of heat accumulators in increasing the efficiency of geothermal heat pumps is incomparable. Heat accumulators increase system efficiency, regulate energy gluing, and provide balance in electrical loading. As a result of their creation on the basis of modern technology, adaptation to automatic control, the economic and environmental advantages of the GIN system are fully manifested. Through the introduction of new devices and technological innovations, energy reliability and safety are increased, a comfortable and economical heat supply is created. The experience of Uzbekistan and other countries around the world has shown that the effective use of heat accumulators in GIN systems is one of the most advanced, future – oriented, fully providing environmental and economic benefits.

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