International Journal of Energy
ISSN: 2957-9473 | Vol. 2, No. 2, 2023

Research status of heat storage technology

Junyi Fang

School of Energy, Chengdu University of Technology, Chengdu, 644005, China
Fang15882186058@163.com

Abstract: With the massive consumption of fossil fuels, the world is gradually facing the problem of energy exhaustion and environmental pollution. Energy plays an intuitive and important role in today's human development and global pattern. The geopolitical crisis caused by this is becoming increasingly fierce and the world energy price wave. In order to seek a more stable source of energy to get rid of the limitations of fossil energy, new energy becomes a new direction of development. In theory, only 23% of the Earth's potential renewable energy (solar, tidal and wind) could be converted to meet today's energy needs, but due to time and geographical factors, utilization is still low. Therefore, the development of heat energy storage technology is of great significance to alleviate energy pressure and promote sustainable development of social economy. In recent years, heat energy storage technology has become one of the most attractive heat energy utilization technologies and has attracted wide attention. At present, it has become a research hotspot worldwide. This paper summarizes the latest research status of heat storage technology in recent years, including the new progress of some technologies. Different heat storage technologies are suitable for different environment and use background, and different energy storage technologies are compared, so as to facilitate the analysis and research of new energy heat storage research under different circumstances.

Keywords: Heat accumulation technology; Phase change heat transfer; Material selection.

1. Introduction

With the massive consumption of fossil fuels, the world is gradually facing the problem of energy exhaustion and environmental pollution. New sources of energy, such as solar, wind and tidal power, are becoming increasingly important. However, it is greatly affected by time and geographical factors, and the utilization rate is still low. Therefore, this paper summarizes the previous relevant heat storage technologies and analyzes the relationship between them

This paper summarizes the latest research status of heat storage technology in recent years, including the new progress of some technologies, different heat storage technology is suitable for different environment and use background, the different heat storage technology is compared, in order to facilitate the analysis and research of new energy heat storage research in different situations.

2. Latent heat accumulation technology

Latent heat storage is the purpose of heat storage and release through phase transformation of heat storage materials [1]. A phase transition reaction is a purely physical reaction at the same temperature in which the heat stored or released in the opposite direction remains unchanged [2]. This heat storage technology can convert heat in a small range and has a high heat storage density [2]. When the heat transfer process is finished, the heat storage material changes from the final state to the initial state, and the cycle of heat storage and heat release is realized. In the process of selecting phase change heat storage materials, various factors such as phase change temperature, thermal stability, heat storage density, latent heat, thermal stability, thermal conductivity and production cost of reference materials should be analyzed [1]. The temperature and latent heat of the phase transition need to be within a certain temperature range to complete the process, so these two factors are very important. In the selection of materials, substances that produce gas are generally not selected. Even though the latent heat content is considerable, gas will bring great instability to the system and hinder the practical application [3]. And under the same environmental conditions, the heat released or stored by the reverse reaction is equivalent. In the process of application and development, capsule encapsulation technology, shaping technology, composite spinning technology and other technologies will be adopted to enhance the service life and heat transfer efficiency of the system by connecting with substances with good heat transfer and stability, and improve problems such as undercooling and leakage [4]. In recent years, the research and development of phase change heat storage materials is a hot topic in the field of heat storage materials. Microcapsule phase change heat storage materials have significant advantages in solving the corrosion, low thermal conductivity and phase separation of traditional phase change heat storage materials [2].

3. Sensible heat accumulation technology

Sensible heat storage is a form of heat storage that mainly stores and releases heat through temperature fluctuation [2]. At present, the main application of sensible heat storage materials are silica, magnesium firebrick, nitrate, cast steel cast iron, crude oil and other materials with large heat capacity. Because of its mature technology development, it is easy to operate and use the equipment. Sensible heat storage materials mainly include water, heat conducting oil, molten salt, pebbles, concrete, cast iron, etc. [3]. However, due to its low heat storage density, large temperature changes in the heat storage/release process, and the need for a large-scale heat storage system, large and complex equipment volume, the temperature difference between materials and the environment will cause large heat loss, so it is not suitable for long-term massive heat storage [2].

At present, there are mainly cross-seasonal heat storage technologies: aquifer heat storage technology, rock heat

storage technology, buried pipe heat storage technology. The heating range can meet the requirements of a large area, and can be either central heating or distributed heating. Taking advantage of the climate characteristics of cold winter and hot summer, heat storage conversion can be carried out. It mainly uses soil, water and other substances for heat storage, which is environmentally friendly [5]. However, it has high dependence on geological and climatic factors, large geographical restrictions, large engineering volume and high cost. Compared with the other two technologies, sensible heat storage technology will still play a leading role in the solar cross-season heat storage market in the short term, such as water tank and soil heat storage, and the system is stable and reliable, and easy to control [5]. The material cost is lower than that of phase change energy storage materials and chemical energy storage materials, which can meet the needs of industrial large-scale use; If it can provide heat storage for solar power plants to provide heat for night and rainy weather to generate electricity; Industrial waste heat can also be recovered for the plant to save energy and improve energy efficiency

4. Chemical heat accumulation technology

Chemical heat storage is the use of chemical reaction in the reversible process accompanied by the absorption and release of heat to achieve the purpose of heat storage. Compared with the other two storage methods, thermochemical heat storage has the advantages of high energy storage density, wide operating temperature range. long storage time, etc. It has been widely used in waste heat recovery and other fields, and can significantly improve the heat quality. The key is the setting of reaction conditions and the selection of materials [6]. Compared with the other two heat storage methods, chemical heat storage has a higher heat storage density, which realizes the mutual conversion of heat energy and chemical energy, avoids heat loss for a long time, and can be reversed when required [7].

For chemical heat storage systems, whether it is the choice of chemical heat storage reaction system or the design of chemical heat storage reactors, the overall performance of the system is significantly affected [8]. Chemical heat storage also has some drawbacks. The general process of chemical reaction is relatively complex, a large number of catalysts are required to make the reaction proceed smoothly, and the stability of the environment is difficult to control, so it is difficult to apply on a large scale [9]. In order to promote the large-scale application of chemical heat storage technology and truly realize from simple theoretical research to engineering practical application, the future research direction should mainly focus on the following aspects.(1) Select the appropriate energy storage system, and study the reaction mechanism and its kinetic characteristics from the overall system on the basis of improving the preparation and synthesis of heat storage materials.(2) Theoretical research and dynamic modeling of heat and mass transfer of porous carrier composite were carried out, and the reactor structure was optimized to obtain high system comprehensive performance.(3) According to the charging temperature (heat source temperature), heat release temperature and application requirements, take into account the reliability and economy of the system, and reasonably design the chemical heat storage system.(4) Carry out the dynamic characteristics of the cycle of chemical heat storage system and model it.(5) Develop and improve the theory and evaluation methods of energy conversion of thermochemical heat storage systems [6].

5. Conclusion

Heat storage technology is a promising resource saving and environment friendly technology, which has attracted much attention in recent years. Sensible heat storage is the most widely used at present. Compared with other heat storage technologies, its basic materials are more abundant, the implementation cost is lower, and it has a simpler heat transfer enhancement technology, which is easier to improve heat transfer efficiency. So it was promoted by researchers. However, the heat storage materials used in this process have low heat storage density and low utilization rate [10]. Therefore, sensible heat storage technology requires the use of large volume and complex process of mechanical equipment in order to obtain enough heat storage. In addition, due to the temperature difference between the heat storage material and the environment, the process of heat storage and release will cause a large amount of heat loss, so it is not suitable for long-term heat storage, which hinders the promotion of this technology [11]. Latent heat storage technology has high heat storage density and can convert heat in a small range. When the heat transfer process is finished, the heat storage material changes from the final state to the initial state, and the cycle of heat storage and heat release is realized. However, in the process of heat storage and heat release, phase transformation heat involving gas will generate gas, which is not conducive to control, and it is difficult to be applied in actual production [1]. In contrast, solid - liquid phase variable heat storage is easier to be produced and applied in practice. Thermochemical heat storage is a reversible process by using the reversible principle of chemical reaction. In the process of reaction, heat energy and chemical energy transform into each other. Chemical heat storage has many advantages, but the process involved is also complicated. Sometimes a reversible chemical reaction may require a large number of catalysts to complete heat storage or heat release, and the cost of reaction control and materials of this technology is still very high [12]. At present, the technology is not mature, and the control of heat storage and heat release in the reaction process is very difficult. It is still in the stage of small-scale experiment and has not been put into large-scale application.

References

[1] Li, Z., Li, B., Chen, H., et al. (2020) Phase change thermal storage technology research progress. Chemical Engineering Progress, 33 (12) 6:5066-5085.

[2] Yu, X, Luan, J. (2020) Research progress of heat storage technology. Chemical Engineering Management, 11:117-118.

[3] Peng, H., Xiong, Y, Lin, C., et al. (2017) Research status and development trend of heat storage materials. Energy Storage Science and Technology, 6(05):1058-1075.

[4] Wang, W., Yang, X., Fang, Y, et al. (2005) Research progress of heat transfer enhancement in latent heat storage system. Renewable Energy, 05:18-22.

[5] Zhao, X., Zhao, Y., Wang, J., et al. (2017) Research progress of solar energy interseasonal heat storage technology. Advances in New Energy, 5(01):73-80.

[6] Yan, T., Wang, W., Wang, R. (2018) Research status and progress of chemical adsorption heat storage technology. Materials Reports, 32(23):4107-4115+4124.

[7] Weng, L., Zhang, Y., Jiang, L., et al. (2020) Based on salt hydrate research progress of thermal chemical adsorption heat storage technology. Energy Storage Science and Technology, 9 (6):1729-1736.

[8] Wang, T., Yan, J., Zhao, C. (2020) Study on Granulation of CaO/Ca(OH)2 Thermochemical heat storage Materials. Journal of Engineering Thermophysics, 41(08):2013-2019.

[9] Hao, M., Liu, H., Wang, W., et al. (2020) Salt hydrate thermal chemical research progress of thermal storage material. Energy Storage Science and Technology, 9 (3): 791-796.

[10] Meng, F., An, Q., Guo, X., et al. (2016) Regenerative process intensification technology application research progress. Chemical Engineering Progress, 35 (5):1273-1282.

[11] Zhao, Y. (2018) Research status and development prospect of solar energy cross-season heat storage heating technology. Management and Technology of Small and Medium-sized Enterprises (ten-day issue), 05:135-137.

[12] Jiang, Z., Zou, B., Cong, L., et al. (2022) Thermal storage technology research progress and prospect. Energy Storage Science and Technology, 9:2746-2771.