News & Views

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Challenges in various thermal energy storage technologies

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With the worsening of energy shortage and environmental pollution, energy storage has received much attention in the fields of renewable and sustainable energy in recent years. It is widely known that energy storage is a technique storing excess energy in one form and converting it back to the same form or another when necessary [1]. Especially energy storage occupies an important position in solar energy, wind energy and ocean energy. Generally, energy storage methods include mechanical energy storage, electrical energy storage and thermal energy storage (TES) [2]. Due to the use of natural resources, mechanical energy storage has advantages of environmental protection, large scale, long life cycle and low operation costs. And electrical energy storage has advantages in some areas like convenient application, low pollution and high conversion efficiency. Mechanical energy storage usually can be subdivided into pumped-hydro energy storage, compressed air energy storage, flywheel energy storage, etc. Electrical energy storage can be divided into battery energy storage, flow battery energy storage, superconducting magnetic energy storage and super capacitor energy storage, etc. In the face of various energy storage technologies, how will thermal energy storage accelerate its development and application?

According to the material property, thermal energy storage can be classified as sensible heat storage, thermochemical heat storage and latent heat storage [3]. The classification of thermal energy storage materials is shown in Fig. 1. Sensible heat storage is achieved by changing the temperature of the storage material without changing its phase. The storage performance of a storage system depends on the specific heat and density of the storage material. Sensible heat storage material can be liquid materials (water, oil, etc.) or solid materials (rock, soil, sand, etc.). Liquid materials can be used for storage and as a transport medium in thermal energy field. Water is one of the most commonly used thermal storage material for low temperature, which is widely used in solar energy system. In the intermediate and high temperature ranges, molten salt and oil are candidate sensible storage materials. They are widely used in power tower systems and metallurgical industries as thermal energy storage and heat transport fluid. Solid media storage avoids the drawbacks of high vapor pressure and other limitations of liquid. However, the disadvantages of large size and temperature swing are inherent in most sensible heat storage. Especially, a large size thermal storage system features large space, high cost and great thermal losses. Further research is needed to reduce the size of thermal storage system by increasing thermal capacity.

Thermochemical heat storage can absorb and release large amounts of thermal energy when the molecular bonds of substance are broken and reformed in a completely reversible chemical reaction. The thermal storage performance of thermochemical heat storage system is determined by working conditions, dynamic characteristics and reversibility of the material. In recent years, many researches on thermochemical materials (such as salt hydrates, methane, carbonates and metal hydride) have exhibited its great prospects of application in thermal energy storage.