Thermal energy storage: Recent developments and practical aspects

Huili Zhang, Jan Baeyens, Gustavo Cáceres, Jan Degrève, Yongqin Lv

Abstract

Thermal energy storage (TES) transfers heat to storage media during the charging period, and releases it at a later stage during the discharging step. It can be usefully applied in solar plants, or in industrial processes, such as metallurgical transformations. Sensible, latent and thermo-chemical media store heat in materials which change temperature, phase or chemical composition, respectively. Sensible heat storage is well-documented. Latent heat storage, using phase change materials (PCMs), mainly using liquid-solid transition to store latent heat, allows a more compact, efficient and therefore economical system to operate. Thermo-chemical heat storage (TCS) is still at an early stage of laboratory and pilot research despite its attractive application for long term energy storage.

The present review will assess previous research, while also adding novel treatments of the subject. TES systems are of growing importance within the energy awareness. TES can reduce the LCOE (levelized cost of electricity) of renewable energy processes, with the temperature of the storage medium being the most important parameter. Sensible heat storage is well-documented in literature and applied at large scale, hence limited in the content of the present review paper. Latent heat storage using PCMs is dealt with, specifically towards high temperature applications, where inorganic substances offer a high potential. Finally, the use of energy storage through reversible chemical reactions (thermo-chemical storage TCS) is assessed. Since PCM and TCS storage media need to be contained in a capsule (sphere, tube, sandwich plates) of appropriate materials, potential containment materials are examined. A heat transfer fluid (HTF) is required to convey the heat from capture, to storage and ultimate re-use. Particle suspensions offer a valid alternative to common HTF, and a preliminary assessment confirms the advantages of the upflow bubbling fluidized bed and demonstrates that particulate suspensions enable major savings in investment and operating costs.

Novel treatments of the TES subject in the review involve the required encapsulation of the latent and chemical storage media, the novel development of powder circulation loops as heat transfer media, the conductivity enhancement of PCMs, the use of lithium salts, among others.

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