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PHASE CHANGE MATERIALS FOR THERMAL STORAGE IN THE RANGE (100-200)°C

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1. A general overview of PCMs

In recent years, attention has been shifted towards renewable and clean energy. Phase change material (PCM) has implemented extensively in many studies thanks to their ability to store and release large amounts of heat with small unit volume under relatively constant temperature.

During the phase change process and according to energy conservation Law, energy is neither destroyed nor created but transferred from one form to another. PCMs absorb heat and convert it, for example, from a solid-state to a liquid state. The process of energy storage during heat absorption is called the charging phase (melting). In contrast, materials release energy when their ambient temperature is less than the PCMs temperature until they become in thermal equilibrium with their surroundings (according to the law of thermal equilibrium or Newton's zeroth law). The process of releasing energy to their surroundings is the discharging phase (solidification).as shown in Fig. 1. PCMs can efficiently manage the energy in different applications by storing the heat during the melting/charging phase and releasing it during the solidification/discharging phase.

Considering their chemical composition, PCMs are mainly divided into organic, inorganic, and eutectic materials. Each category has a specific range of operating temperatures and thermo-physical properties, which make it more suitable for specific applications than other categories.

Generally speaking, there are three types of storage methods, namely the sensible, latent and thermochemical storage. Storage capacity varies among each type, for instance, sensible storage capacity almost two times greater than that of PCM. Therefore, latent heat storage can be used in a wide temperature range.

2. General and desired characteristics of PCMs

PCM should accomplish the desired properties to be used in the design of thermal storage systems. In this regard, lists the typical characteristics of the mentioned three categories and points out their main advantages and disadvantages.

From the other side, there are several preferable characteristics of PCM to be used effectively. These characteristics can be divided into several groups, as follows:

2.1 Thermo-physical Properties

- The melting temperature of PCM and the operating temperature should be within the same range.
- The volume required for the container to store a certain amount of energy should be minimal. Therefore, the latent heat of fusion must be high per unit volume.
- The specific heat must be high to supply additional noteworthy sensible heat storage.
- For further assistance the charging and discharging of the energy of the storage systems, the PCM must have a high thermal conductivity of both solid and liquid phases.
- The volume change is small during the phase change, and the vapour pressure is low at the working temperature to reduce the containment problem.
- Suitable melting and constant storage capacity for each cycle.

2.2 Kinetic properties

- High nucleation rate to avoid super-cooling during the liquid phase.
- High crystal growth rate so that the system can meet the requirements of recovering heat from the storage system.

2.3 Chemical properties

- Chemical stability.
- Complete a reversible freeze/melting cycle.
- There is no degradation after a large number of freeze/melting cycles.
- Does not corrode with other materials (compatibility).

3. PCMs working range focusing on (100-200 ^{o}C).

3.1. Non-paraffin PCM

It is the largest category of candidate materials for latent heat storage. Many researchers have conducted an extensive survey, and many esters, fatty acids, alcohols and glycols suitable for energy storage have been identified. These organic materials are other subcategories of fatty acids and other non-paraffin organics. Non-paraffin organics are the largest number of PCMs, with a variety of characteristics. Unlike paraffin, each material has its characteristics, while paraffin has very similar characteristics. These materials are flammable and should not be exposed to excessive temperatures, flames or oxidants.

3.2. Fatty Acids

The fatty acid characterized by the chemical formula $CH_3(CH_2)_{2n}COOH$ has the same characteristics as paraffin wax. The advantages of sharper phase transitions are offset by the disadvantages of twice or three times the cost of paraffin wax .

3.3. Salt Hydrates

Salt hydrate is the oldest and most studied PCM for heat storage. They are composed of salt and water, and when the material solidifies, they merge into a crystalline matrix. They can be used alone or in the form of a eutectic mixture .Table 3 shows the properties of some salt hydrates with melting points ranging from (100 to 200) ℃ .

Salt hydrates are the most crucial category of PCMs, and extensive research has been conducted on their use in latent heat storage systems.