2.4 Thermal Energy storage system with PCM:

2.4.1 Latent Heat Storage (Storage in Phase Change MaterialsPCM)

In this class of storage, energy is stored by virtue of latent heat of change of phase of the storage medium. Phase change materials have considerably higher thermal energy storage densities as compared to sensible heat storage materials and are able to absorb or release large quantities of energy at a constanttemperature. Therefore, these systems are more compact but more expensive than sensible heat storage systems.

Various phase changes that can occur are:

- solid-solid (lattice change)
- solid-gas
- solid-liquid
- liquid-gas

Solid-gas and liquid-gas transformations are not employed in spite of large latent heats as large changes in volume make the system complex and impracticable. In solid-solid transition, heat is stored as the material is transformed from one crystalline form to another. These transitions involve small volume changes;however, most of them have small latent heats.

For phase-change storage media, salt hydrates called Glauber‟s salt ($Na_2SO_4.10H_2O$) are preferred. The solid-liquid transformations include storage in salt hydrates. Certain inorganic salts, which are soluble in water and form crystalline salt hydrates, are employed. Let an inorganic salt, which is soluble in water represented by X(Y) n. The crystalline salt hydrate is symbolized by X(Y) n. mH2O. On heating up to transition temperature, the hydrate crystals release water of crystallization and the solid remainder (anhydrous salt) dissolves in the released water as following reaction takes place:

$$\underset{\text{(Solid)}}{X(Y)_n.\, m\mathrm{H_2O}} + \Delta\mathrm{H} \leftrightarrow \underset{\text{(Liquid: aqueous solution of anhydrous salt)}}{X(Y)_n + m\mathrm{H_2O}}$$

One problem with most salt hydrates is that the released water of crystallization is not sufficient to dissolve all the solid phase present. Due to density difference, the anhydrous salt settles down at the bottom of the container. This incongruent melting makes the process irreversible since the anhydrous salt at the bottom is unable to find water for recrystallization to the original hydrate. The recrystallization of an incongruently melting salt can be achieved either by (i) the use of suspension media or thickening agent or by (ii) mechanical means (vibration, stirring, etc.)

Other potential phase change materials apart from salt hydrates are paraffin"s (e.g. C18 H38, etc., alkanes containing 14 to 40 C-atoms) and non-paraffin organic materials (e.g. esters, fatty acids, alcohols and glycols), which are suitable at certain situations.

2.4.2 Heat transfer properties of phase change storage materials:

S.N.	Material	Chemical compound	Melting point (°C)	Heat of fusion (kJ/kg)	Density kg/m^3
1.	Sodium sulphate decahydrate (Glauber's salt)	$Na_2SO_4 . 10H_2O$	31–32	251	1534
2.	Sodium thiosulphate	$Na_2S_2O_3 . 5H_2O$	48–49	209	1666
3.	Calcium chloride hexahydrate	$CaCl_2 . 6H_2O$	29–39	177	1634
4.	Sodium carbonate dehydrate	$Na_2CO_3 . 10H_2O$	32–36	247	1442
5.	Disodium phosphate decahydrate	$Na_2HPO_4 . 12H_2O$	36	265	1522