## 1.1General Chapter 1

Solar energy being simple to use, clean, non polluting and inexhaustible has received wide spread attention in recent times. It provides well abundant energy source if utilized efficiently. But this energy is time dependent energy source with an intermittent character. Hence some form of thermal energy storage is necessary for more effective utilization of this energy source Phase Change Material (PCM) is one of the techniques to store this thermal energy in the form of latent heat. Both organic and inorganic phase change materials (PCM) have large amount of heat energy stored in the form latent heat which is absorbed or released when materials changes state from liquid to solid or solid to liquid .The PCM retains its latent heat without any change in physical or chemical properties over thousands of cycles. This PCM has wide range of applications; one of them is in the solar water heater. One of the options is to develop energy storage devices, which are as important as developing new sources of energy. Energy storage not only reduces the mismatch between supply and demand but also improves the performance and reliability of energy systems and plays an important role in conserving the energy. It leads to saving of premium fuels and makes the system more cost effective by reducing the wastage of energy and capital cost.

Energy is essential for the existence of human life and plays vital role in the progress of the nation. However the past few years have witnessed a rapid growth in global population putting a tremendous burden on energy resources .In the present scenario the importance of available energy can’t be under Estimated. Also due to fast growth of the Indian economy. The country’s energy demand has grown to an average of 3.65% per annum over the past 30 years so it has become a need to harness alternate and renewable energy sources. Today India has one of the highest potential for the effective use of renewable energy sources .The country has also invested heavily in recent years in renewable energy utilization.

## 1.2 Sensible heat

When an object is heated, its temperature rises as heat is added. The increase in heat is called sensible heat. Similarly, when heat is removed from an object and its temperature falls, the heat removed is also called sensible heat. Heat that causes a change in temperature in an object is called sensible heat.

## 1.3Latent heat

All pure substances in nature are able to change their state. Solids can become liquids (ice to water) and liquids can become gases (water to vapor) but changes such as these require the addition or removal of heat. The heat that causes these changes is called latent heat. Latent heat however, does not affect the temperature of a substance - for example, water remains at 100c while boiling. The heat added to keep the water boiling is latent heat. Heat that causes a change of state with no change in temperature is called latent heat. Appreciating this difference is fundamental to understanding why refrigerant is used in cooling systems. It also explains why the terms 'total capacity' (sensible heat & latent heat) and 'sensible capacity' are used to define a unit's cooling capacity. During the cooling cycling, condensation forms within the unit due to the removal of latent heat from the air. Sensible capacity is the capacity required to lower the temperature and latent capacity is the capacity to remove the moisture from the air. [2]

## 1.4 Paraffin wax

Paraffin wax consists of a mixture of mostly straight chain n-alkenes CH3 (CH2)-CH3. The crystallization of the (CH3) - chain release a large amount of latent heat. Both the melting point and latent heat of fusion increase with chain length. Paraffin qualifies as heat of fusion storage materials due to their availability in a large temperature range. Due to cost consideration, however, only technical grade paraffin's may be used as PCMs in latent heat storage systems. Paraffin is safe, reliable, and predictable, less expensive and non corrosive. They are chemically inert and stable below 500°C, show little volume changes on melting and have low vapor pressure in the melt form. For these properties of the paraffin's, system-using paraffin's usually have very long freeze-melt cycle. The thermal properties of some technical grade paraffin's, which are essentially, paraffin mixtures and are not completely refined oil. The melting point of alkenes increases with the increasing number of carbon atoms. Apart from some several favorable characteristic of paraffin's, such as congruent melting and good nucleating properties. They show some undesirable properties such as: (i) low thermal conductivity, (ii) no compatible with the plastic container and (iii) moderately flammable. All these undesirable effects can be partly eliminated by slightly modifying the wax and the storage unit. Some selected paraffin's are along-with their melting point, latent heat of fusion and groups. PCMs are categorized as: (i) group I, most promising; (ii) group II, promising; and (iii) group III, less promising. [3]

### 1.4.1 Specifications of Paraffin Wax

- Product name: Paraffin wax
- Generic name: Paraffin wax
- Chemical family: Mineral wax
- Health hazards: None anticipated
- Physical hazards: This material may but will not ignite readily. Keep away from all sources of ignition.
- Physical form: Solid-slab or pastille form
- Appearance: White
- Odor: None to slight-characteristic.
- Flash point: 400 degrees f minimum
- Boiling point:>650degree
- Melting point: 50-65
- Solubility in water: Negligible
- Specific gravity: Approximately 0.96
- Chemical stability: Stable under normal condition of storage and handling

### 1.4.2 Specifications of Lauric acid

- Physical State: Flakes
- Color: white
- Odor: Not available
- pH: Not available
- Vapor Pressure: 1 mm Hg @ 121 deg C
- Vapor Density: Not available
- Evaporation Rate: Not available

- Viscosity: Not available
- Boiling Point: 225 deg C @ 100.00m ( 437.00□F)
- Freezing/Melting Point: 44 - 46 deg C
- Decomposition Temperature: Not available
- Solubility in water: insoluble
- Specific Gravity/Density: .8830g/cm3
- Molecular Formula: $C_{12}H_{24}O_2$
- Molecular Weight: 200.32

## 1.5 Evacuated tubes


Figure 2.5 Evacuated Tube

Evacuated tubes are the absorber of the solar water heater. They absorb solar energy converting it into heat for use in water heating. There are several types of evacuated tubes in use in the solar industry. Apricus collectors use the most common "twin-glass tube". This type of tube is chosen for its reliability, performance and low manufacturing cost. Each evacuated tube consists of two glass tubes made from extremely strong borosilicate glass. The outer tube is transparent allowing light rays to pass through with minimal reflection. The inner tube is coated with a special selective coating which features excellent solar radiation absorption and minimal reflection properties. The top of the two tubes are fused together and the air contained in the space between the two layers of glass is pumped out while exposing the tube to high temperatures. This "evacuation" of the gasses forms a vacuum, which is an important factor in the performance of the evacuated tubes. Why a vacuum? As you would know if you have used a glass lined thermos flask, a vacuum is an excellent insulator. This is important because once the evacuated tube absorbs the radiation from the sun and converts it to heat; we don't want to lose it!! The vacuum helps to achieve this. The insulation properties are so good that while the inside of the tube may be 150°C / 304°F, the outer tube is cold to touch. This means that evacuated tube water heaters can perform well even in cold weather when flat plate collectors perform poorly due to heat loss.

In order to maintain the vacuum between the two glass layers, a barium getter is used. During manufacture of the evacuated tube this getter is exposed to high temperatures which cause the bottom of the evacuated tube to be coated with a pure layer of barium. This barium layer actively absorbs any CO, CO2, N2, O2, H2O and H20utgassed from the evacuated tube during storage and operation, thus helping to maintaining the vacuum. The barium layer also provides a clear visual indicator of the vacuum status. The silver colored barium layer will turn white if the vacuum is ever lost. This makes it easy to determine whether or not a tube is in good condition.

### 1.5.1 Specification of Evacuated Tube

- Material used for evacuated tube = Glass
- Length of the evacuated tube = 1.8m
- Diameter of the evacuated tube= 0.058m
- Volume of the evacuated tube = $\pi/4 \times 0.058^2 \times 1.8$

## 1.6 Copper

Copper is a chemical element with the symbol Cu (Latin: cuprum) and atomic number 29.1t is a ductile metal with very high thermal and electrical conductivity. Copper is soft and malleable, and exposed surface has a pinkish or peachy color. It is used as a thermal conductor, an electrical conductor, a building material, and a constituent of various metal alloys.

Copper compounds are known in several oxidation states, usually +2, where they often impart blue or green colors to natural minerals such as turquoise and have been used historically widely as pigments. Copper metal architectural structures and statuary eventually corrode to acquire a characteristic green patina. Copper as both metal and pigmented salt, has a significant presence in decorative art. Thermal conductivity of the copper is defined as the quantity of heat transmitted through a unit thickness in a direction normal to a surface of unit area, due to a unit temperature gradient under steady state conditions.

## 1.7 Scope of the project

- To utilize the renewable energy like solar energy for the purpose of water heating.
- Increase the performance efficiency of the solar water heater by using different Phase Change Materials (PCM'S).
- Heat energy stored for longer period of time in the form of latent heat and sensible heat.