A Review Paper on Thermal Energy Storage

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ABSTRACT:

There is an new technology, including exhaust conditioning devices and design modification, those improvement in fuel consumption rate will cause problem in other areas by using for an smaller engine with an less overall energy conversion result in the reduction of available heat to warm up the passenger compartment and the engine. It use to improvement in the standard of living continues to play an increasingly vital role in the society; on the surrounding of air pollution are becoming more stringent. This subsequently causes an increase in warm-up time that has a negative impact on passenger comfort and intensifies the cold-start problem.

Keywords – *Phase change material (PCM), Thermal Energy Storage, Renewable Energy, Latent Heat of Thermal Energy Storage (LHTES), High Energy Density, Thermochemical Energy Storage.*

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1. INTRODUCTION

There exist several TES technologies and applications. The selection of a TES technology for a specific application depends on many criteria, including the storage duration, cost, supply and utilization temperature requirements, and storage capacity. For many years, TES devices and systems have been utilized in building designs and integrated into solar power-generation, but the application of TES in the automobile industry did not start until the late 1970s

There are various potential applications of TES (Thermal Energy Storage) in the automotive industry. First, a TES device could be charged from an engine’s waste heat during normal operation. In addition, TES devices could be utilized to provide heat during warm-up to reduce fuel consumption and emission. The drivers can avoid waiting for preheating and warming the engine. Moreover, TES devices have potential applications in hybrid and electric vehicles powered by batteries. Since the batteries operate poorly at low temperatures, the use of a TES device for rapid heating of the batteries could

Alleviate the degradation of battery performance in cold weather. Finally, a TES device could be used to enhance passenger comfort and aid in defrosting of windshields. In cold weather, it could take several minutes to provide significant warming in the passenger cabin before the internal combustion engine could spare enough heat. For electric vehicles, the situation would be even worse due to the lack of a high-temperature heat source. Since TES devices could produce heat directly without sharing with other compartments, they would be able to provide the thermal energy more efficiently and thereby greatly enhance the operation of vehicles during winter.

Thermal Energy Storage (TES) devices have attracted profound interest from researchers for their use in eliminating environmental problems and increasing the efficiency of energy consumption in general. TES devices store thermal energy (heat) in hot or cold materials for later use. It is an important technology in bridging the gap between the supply and demand of energy. Thus, TES devices allow the reutilization of stored energy to drive energy systems and prove to be extremely beneficial for renewable energy applications. They can also be used to mitigate the cold engine startup problem. As There are various potential applications of TES in the automotive industry. First, a TES device could be charged from an engine’s waste heat during normal operation. In addition, TES devices could be utilized to provide heat during warm-up to reduce fuel consumption and emission. The drivers can avoid waiting for preheating and warming the engine.

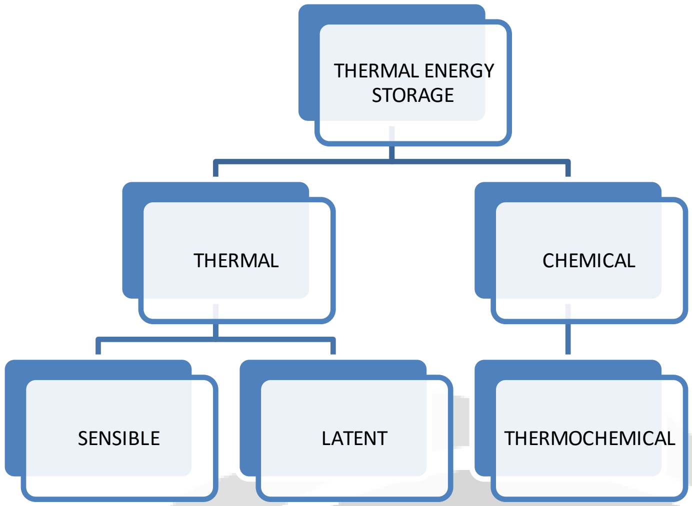

Fig 1 :-Different types of thermal energy storage device

1.1 Sensible Heat Thermal Energy Storage:-

Sensible heat storage devices store thermal energy by heating or cooling the temperature of the storage material through heat transfer. Sensible heat TES devices take advantage of the heat capacity and the change in temperature of the material during the charging and discharging processes. The amount of energy stored in a sensible TES device depends on the mass and specific heat of the storage medium, and the temperature difference of the storage medium between its initial and final states. The total amount of heat stored can be expressed as:

$$Q=\int_{Ti}^{Tf} mCpdT$$

Q= m Cp (Tf-Ti)

Among all potential media for sensible heat storage, water has been the most promising candidate. Due to its high heat capacity (~4.2 kJ/kg · K) and low cost, it is often used in storage devices over the temperature range of 20-70oC. Also, as a liquid storage medium with high convective heat transfer, water allows the storage device to have higher heat injection and extraction rates compared to other solid heat storage media.

Due to their simplicity and low cost, sensible heat TES devices have been used in the automotive industry. Generally, they reserve a hot coolant in the storage phase and release the hot coolant into the engine circuit during the cold start.

However, sensible heat storage devices are not great candidates for long-term or automobile applications because of the following drawbacks

- Low energy storage density (~100 kJ/kg),
- Heavy insulation required to minimize heat loss to the ambient,
- Non-isothermal behavior during charging and releasing processes.

1.2 Thermochemical Energy Storage:-

Thermochemical energy storage devices use a reversible chemical reaction to store and release energy. It stores heat in the process of dissociation reaction and releases the energy in the exothermic step of a reversible chemical reaction.

Thermochemical storage has not been developed commercially, but its advantages have drawn significant attention

High energy storage density (~2MJ/kg)

- No or low heat losses.
- Long-term storage period.
- Long distance transport possibility.
- Small storage volume.

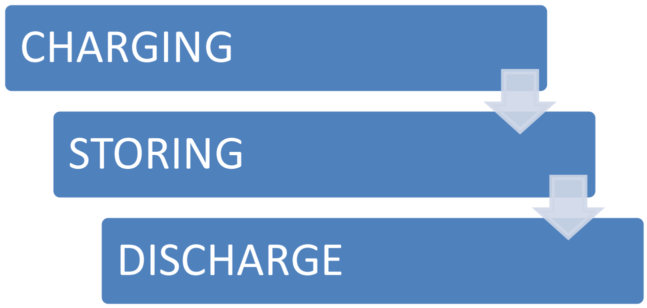

Fig 2 :Process of Thermochemical TES Cycle

1.3 Latent Heat Storage:-

In general, the latent heat storage is the most promising amongst different methods of thermal energy storage. In latent heat TES, energy is stored in the phase change materials (PCMs) through the change of a substance from one phase to another. As the temperature increases, the material transforms from solid to liquid phase and absorbs heat in the endothermic process. When temperature is reduced, the material undergoes phase change from liquid to solid and releases heat. Since PCM's store energy in the form of latent heat of fusion, there is no significant temperature drop in the heat release process.

The energy storage has to go through several phase transitions: solid-solid, solid–liquid, solid–gas and liquid–gas. In solid-solid transition, energy is stored by the crystalline transformation of the material. This transition contains much smaller latent heat and minor volume changes. As a result, solid-solid PCMs have the advantage of less strict container requirements that allow greater design flexibility. On the other hand, solid-liquid transformation plays an important role in the latent heat TES since it provides a high energy storage density and has much higher latent heat of fusion. In contrast to solid-solid and solid-liquid phase transitions, solid-gas and liquid-gas transitions have the advantage of higher latent heat of fusion, but their large volume change during the phase change process increases the difficulty and complexity of the storage system.

Overall, the amount of energy stored in latent heat TES devices depends on the heat of absorption or release during phase change, which can be calculated as:

$$Q=\int_{Ti}^{Tm} mCpdT + m a_m \Delta h_m$$

where *m* and *Cp* denote the mass and specific heat of the storage material, respectively, (*Tm* - *Ti*) is the temperature difference between the initial and the melting temperatures of the storage material, *am* is the extent of conversion, and *Δhm*is the latent heat of fusion of the storage material .

Compared to sensible heat TES, latent heat TES has benefits of higher heat storage density, small size of the system, reduced segregation of components, minor changes in structure during repeated phase transitions, and low cost . However, several drawbacks in latent TES such as poor heat transfer rate, short-term stability, high super-cooling effects, and low thermal conductivity, have prevented it from a wide commercial use.

2. LITERATURE REVIEW

Indian forces are working in very harsh environment in hot deserts at western border and cold deserts at high altitudes. Performance of man, equipment, and weapon system especially sensors and electronics, get adversely effected in harsh environment of desert, many times, leading to failure of critical equipments. Use of PCM can provide practical solutions to many of these problems. Defense Laboratory, Jodhpur (DLJ) has taken up a R&D program to develop PCM-based products to meet requirements of Armed Forces. Present paper describes status of science and technology of PCM along with materials and products developed at DLJ.PCM is very important topic for more innovations, because this materials can be enhance for more special applications. This material has wide range of applications and it can be increased by enhancing the PCM by adding some proper additives [3].

This paper presents modeling results of an innovative system for the temperature control in the interior compartment of a stationary automobile facing the solar energy from the sun. A very thin layer of PCM inside a pouch placed in the ceiling of the car in which the heating energy is absorbed and released with melting and solidification of phase change material. As a result the temperature of the car interior is maintained in the comfort condition [7]

Latent heat storage in a Phase Change Material (PCM) is very attractive because of its high storage density with small temperature swing. It has been demonstrated that, for the development of a latent heat storage system, the choice of the PCM plays an important role in addition to heat transfer mechanism in the PCM. The paper contains a list of about 250 PCMs and more than 220 references. Latent heat storage can be accomplished through solid-liquid, liquid-gas, solid-gas, and solid-solid phase transformations, but the only two of practical interest are the solid-liquid and solid-solid. Of the two practical systems, the solid-liquid system is the most studied and most commonly commercially available. Solid-solid systems shows much promise, but are only recently being studied and most commonly commercially available. Solid-solid systems shows much promise, but are only recently being studied. Many phase change materials (PCMs) have been studied for practical use. This paper is a compilation of much of practical information on different PCMs and system developed based on latent heat storage technology [2].

This work investigates experimentally the performance of a thermal energy storage unit with phase change material encapsulated in cylinders. Air is the heat transfer fluid that flows across the tube banks to charge and discharge the storage system. The investigation analyses the storage system in terms of its storage capacity and the heat transfer rate to the phase change material. The aim of the analysis is to offer a solid ground for scaling up and implementation on solar residential domestic heating applications [6].

The use of a latent heat Eutectic aluminum silicon alloy, AlSi12, is an attractive phase change material because of its moderate melting temperature, high thermal conductivity, and high heat of fusion. n. A prototype thermal energy storage test rig has been built and tested as to better understand the behavior of latent heat thermal energy storage. A mathematical model was developed to predict the behavior of such a heat storage unit. The model was compared with the behavior of the test rig during discharge. The model proved to simulate the latent heat thermal energy storage with reasonable accuracy. It is recommended that more accurate material property data be obtained and that the thermal energy storage test rig be modified as to improve readings [5].

storage system using phase change materials (PCMs) is an effective way of storing thermal energy and has the advantages of high-energy storage density and the isothermal nature of the storage process. PCMs have been widely used in latent heat thermal storage systems for heat pumps, solar engineering, and spacecraft thermal control applications. The uses of PCMs that melt and solidify at a wide range of temperatures, making them attractive in a number of application. This paper also summarizes the investigation and analysis of the available thermal energy storage systems incorporating PCMs for use in different applications [1].

Polyethylene glycol/silicon dioxide composite, a kind of form-stable phase change material. The composites can be made into mortar which is able to adhere to the surface of building structure and absorb the fire heat. This aims to study the effect of the composites on the fire resistance of building structure [4].

3. CONCLUSION

The primary application of the latent heat TES devices is to store waste heat from an automobile engine during its operation and to provide the stored energy to warm up the engine components in cold weather and at start.

4. FUTURE SCOPE

Material durability tests should be carried out to assure the long-term thermal cycling performance of the TES device. Before commercialization of the product, the latent heat TES has to show reliability and durability closely matching the average lifespan of a vehicle. And To further improve the performance of the latent heat TES device. Compared to increasing the cooling water flow rate which would require a larger pump and greater power, this method could be more cost-effective.

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