Survey on Thermal Energy Storage Unit to Enhance a Workshop Heating System Driven by Industrial Residual Water

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Abstract : The use of a latent heat 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 for heating and cooling applications for buildings have been investigated within the past decade**.** This paper also summarizes the investigation of different research papers are studied related to the Thermal Energy Storage Unit to Enhance a Workshop Heating System Driven by Industrial Residual Water.

***IndexTerms* - industrial residual water (IRW); thermal energy storage (TES); phase change material (PCM); paraffin wax; workshop heating.**

I. INTRODUCTION

In the last decades, the increase in energy demand, together with a growing awareness of the limitation of emissions of greenhouse gases and pollutants, resulted in a significant impulse to the development of technologies aimed at energy saving and at the production of energy from renewable sources. The Intergovernmental Panel on Climate Change (IPCC) report shows that humankind plays a fundamental role on climate change owing to CO2 emissions from energy consumption, and that a significant reduction in CO2 emissions is necessary within next decades. The use of renewable energy sources and increased energy efficiency are the main strategies to reduce the dependency of fossil fuels and CO2 emissions. However, as it is known, renewable energy sources such as solar and wind energy in particular, are not only characterized by discontinuous availability but are also affected by random variations due to local weather conditions.

In this scenario, the availability of energy storage would be essential allowing a large number of solutions and combination of different technologies from already existing power generation systems [4]. 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. The energy storage could also be used to offset the temporary decreases of production from conventional energy sources, ensuring the expected level of demand, allowing a reduction of the peak and an improvement of the efficiency of the plant, with the result of fuel savings [5]. The different forms of energy that can be stored include mechanical, electrical and thermal energy (Fig. 1.1).

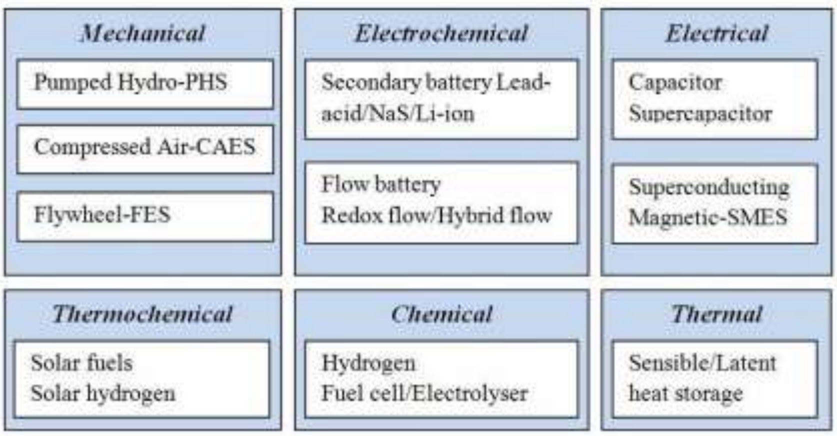

Fig.1Classification of energy storage technologies by the form of stored energy

II. LITERATURE SURVEY

Wenqiang Sun et al.[1] "Thermal Analysis of a Thermal Energy Storage Unit to Enhance a Workshop Heating System Driven by Industrial Residual Water", Various energy sources can be used for room heating, among which waste heat utilization has significantly improved in recent years. However, the majority of applicable waste heat resources are high-grade or stable thermal energy, while the low-grade or unstable waste heat resources, especially low-temperature industrial residual water (IRW), are insufficiently used. A thermal energy storage (TES) unit with paraffin wax as a phase change material (PCM) is designed to solve this problem in a pharmaceutical plant. The mathematical models are developed to simulate the heat storage and release processes of the TES unit. The crucial parameters in the recurrence formulae are determined: the phase change temperature range of the paraffin wax used is 47 to 56C, and the latent heat is 171.4 kJ/kg. Several thermal behaviors, such as the changes of melting radius, solidification radius, and fluid temperature, are simulated. In addition, the amount of heat transferred, the heat transfer rate, and the heat storage efficiency are discussed. It is presented that the medicine production unit could save 10.25% of energy consumption in the investigated application.

Alessia Arteconi et al.[2] “Active demand response with electric heating systems: impact of market penetration”, this paper demonstrates the strict interaction between the demand and the supply side: the behaviour of the flexible electric heating systems is not only dependent on the comfort constraints imposed by the consumers, but also on the boundary conditions under which they operate, such as the RES share in the system and the behaviour of the other consumers. Thus, in order to assess the added value and effects of ADR, it is necessary to take both the demand and supply of the electricity generation into account, for example through an integrated modelling approach. Moreover, beyond the economic evaluation on its convenience, it is worth remembering that ADR is interesting because it is a powerful tool to face the challenges of new energy supply systems, where renewable have a significant role in the electricity generation mix.

Hongting Ma et al.[3] “Experimental study of a multi-energy complementary heating system based on a solar-groundwater heat pump unit”, The use of solar assisted groundwater source heat pump heating system in building can make full use of renewable energy, such as solar energy and geothermal. It can reduce the consumption of primary energy and is energy-saving and environmentally friendly compared with the traditional heating system. Based on the experimental study, the following conclusions can be obtained:

(1) The building heating systems that uses solar-groundwater heat pump units can overcome the instability and other shortcomings of solar energy heating systems, improve the average evaporating temperature and COP of heat pump units, reduce the circulating water temperature of solar collectors and improve the collection efficiency, which will improve the operation economy of the composite heating system.

(2) Taking the indoor effect temperature as the main index evaluating the thermal comfort is more scientific and rational, and it can reflect the superiority of the new system compared with the traditional heating system.

(3) Compared with the traditional heating system, the energy saving rate of floor radiant heating system reaches 18.96%. Taking the basic energy (primary energy) consumption as a benchmark, the solar assisted geothermal energy and radiant floor heating system can reduce energy consumption by 30.55% compared with the traditional regional boiler room heating system.

(4) Economic analysis has been conducted on the new type of heating system and the conventional central heating system, the results shows that it will take 10.6 years to breakeven the life cycle cost for SGHP operating.

(5) As the solar fraction increases from 0 to 100%, the COP of heat pump units and overall system are increased 6.44% and 19.34%, respectively.

Antoni Gil et al.[4] “State of the art on high temperature thermal energy storage for power generation. Part 1—Concepts, materials and modellization”, This paper analyses the information available in the open literature regarding high temperature thermal storage for power generation, with the focus on the classification of storage system concepts; the description of the materials used in these different storage concepts; as well as the review of the physical models used to simulate such systems.

Xing Luo et al.[5] “Overview of current development in electrical energy storage technologies and the application potential in power system operation” This paper provides an overview of the current development of various types of EES technologies, from the recent achievements in both the academic research community and industrial sectors. A comprehensive analysis is carried out based on the relevant technical and economic data, which leads to a number of tables and figures showing a detailed comparison of various EES technologies from different perspectives. Further discussion on EES power system application potentials is given based on the current characteristics of EES and the relevant application specifications. The overview has shown a synthesis of the state-of-the-art in important EES technologies, which can be used for supporting further research and development in this area and for assessing EES technologies for deployment.

Sameer Hameer et al.[6] “A review of large-scale electrical energy storage”, This paper gives a broad overview of a plethora of energy storage technologies available on the large-scale complimented with their capabilities conducted by a thorough literature survey. According to the capability graphs generated, thermal energy storage, flow batteries, lithium ion, sodium sulphur, compressed air energy storage, and pumped hydro storage are suitable for large-scale storage in the order of 10’s to 100’s of MWh; metal air batteries have a high theoretical energy density equivalent to that of gasoline along with being cost efficient; compressed air energy storage has the lowest capital energy cost in comparison to other energy storage technologies; flywheels, super conducting magnetic storage, super capacitors, capacitors, and pumped hydro storage have very low energy density; compressed air energy storage, cryogenic energy storage, thermal energy storage, and batteries have relatively high energy density; high efficiency in tandem with high energy density results in a cost efficient storage system; and power density pitted against energy density provides a clear demarcation between power and energy applications. This paper also provides a mathematical model for thermal energy storage as a battery. Furthermore, a comprehensive techno-economic evaluation of the various energy storage technologies would assist in the development of an energy storage technology roadmap.

III. ENERGY STORAGE METHODS

The different forms of energy that can be stored include mechanical, electrical and thermal energy.

3.1 Mechanical energy storage

Mechanical energy storage systems include gravitational energy storage or pumped hydropower storage (PHPS), compressed air energy storage (CAES) and flywheels. The PHPS and CAES technologies can be used for large-scale utility energy storage while flywheels are more suitable for intermediate storage. Storage is carried out when inexpensive off-peak power is available, e.g., at night or weekends. The storage is discharged when power is needed because of insufficient supply from the base-load plant.

3.2 Electrical storage

Energy storage through batteries is an option for storing the electrical energy. A battery is charged, by connecting it to a source of direct electric current and when it is discharged, the stored chemical energy is converted into electrical energy. Potential applications of batteries are utilization of off-peak power, load leveling, and storage of electrical energy generated by wind turbine or photovoltaic plants. The most common type of storage batteries is the lead acid and Ni–Cd.

3.3 Thermal energy storage

Thermal energy storage can be stored as a change in internal energy of a material as sensible heat, latent heat and thermo chemical or combination of these. An overview of major technique of storage of solar thermal energy is shown in Fig. 2 [7].

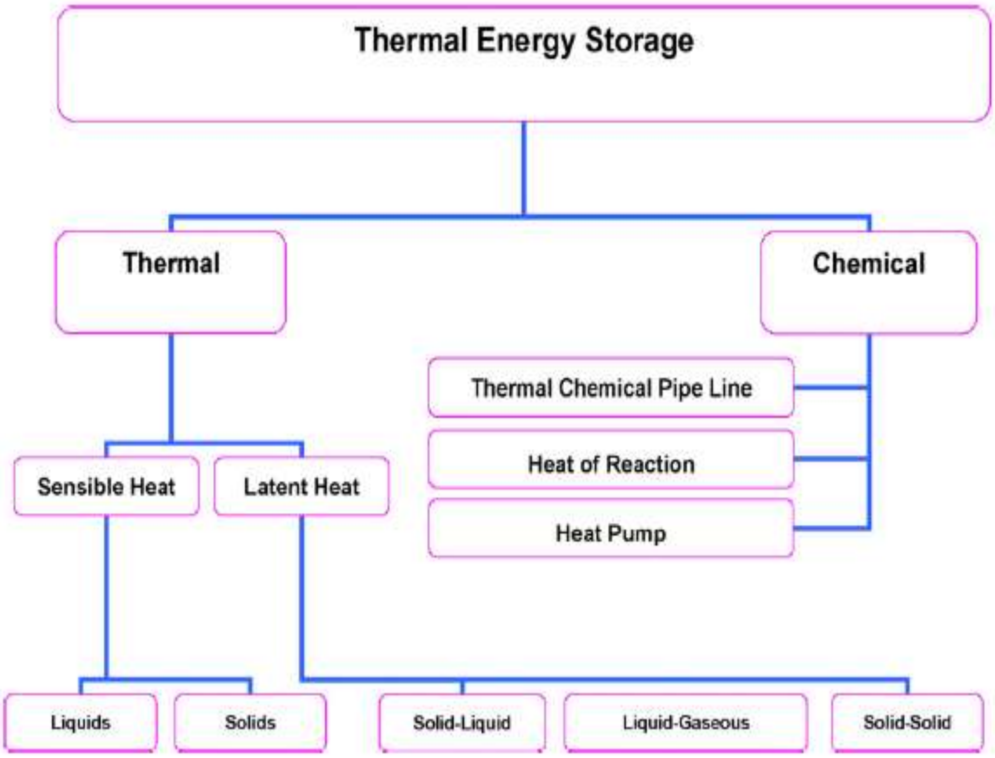

Fig.2. Different types of thermal storage of solar energy

IV. LATENT HEAT STORAGE MATERIALS

Phase change materials (PCM) are ''Latent'' heat storage materials. The thermal energy transfer occurs when a material changes from solid to liquid, or liquid to solid. This is called a change in state, or ''Phase.'' Initially, these solid–liquid PCMs perform like conventional storage materials; their temperature rises as they absorb heat. Unlike conventional (sensible) storage materials, PCM absorbs and release heat at a nearly constant temperature. They store 5–14 times more heat per unit volume than sensible storage materials such as water, masonry, or rock. A large number of PCMs are known to melt with a heat of fusion in any required range. However, for their employment as latent heat storage materials these materials must exhibit certain desirable thermodynamic, kinetic and chemical properties. Moreover, economic considerations and easy availability of these materials has to be kept in mind.

A large number of phase change materials (organic, inorganic and eutectic) are available in any required temperature range. A classification of PCMs is given in Fig. 3.

There are a large number of organic and inorganic chemical materials, which can be identified as PCM from the point of view melting temperature and latent heat of fusion. However, except for the melting point in the operating range, majority of phase change materials does not satisfy the criteria required for an adequate storage media as discussed earlier. As no single material can have all the required properties for an ideal thermal-storage media, one has to use the available materials and try to make up for the poor physical property by an adequate system design. For example metallic fins can be used to increase the thermal conductivity of PCMs, supercooling may be suppressed by introducing a nucleating agent or a 'cold finger' in the storage material and incongruent melting can be inhibited by use of suitable thickness.

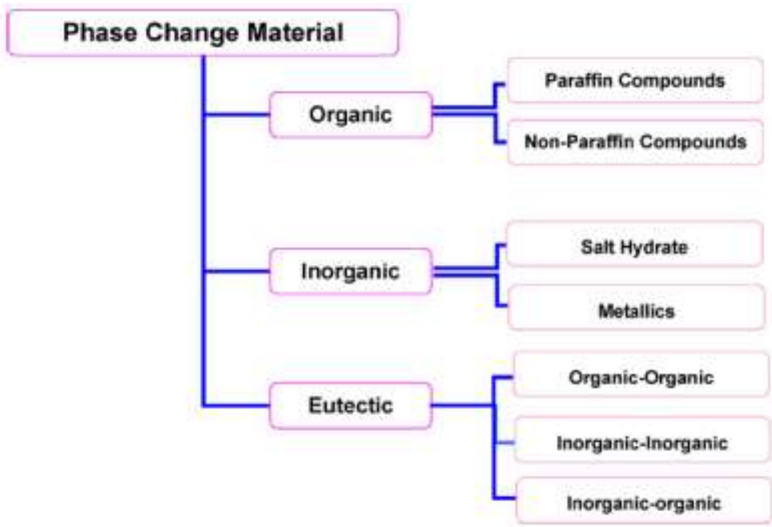

Fig.3. Classification of PCMs

V. CONCLUSION

In this paper gives a broad overview of a plethora of energy storage technologies available on the large-scale complimented with their capabilities conducted by a thorough literature survey. There are three energy storage methods are studied in this paper. It presents introduction and classification of phase change materials which is known as latent heat storage materials. There are large numbers of PCMs that melt and solidify at a wide range of temperatures, making them attractive in a number of applications.

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