CHAPTER I

INTRODUCTION

Background

Solar energy is the most abundant energy source compared with another energies and supply's unlimited clean energy. Solar energy can be transferred to thermal energy via a collector and send to the equipment by heat transfer fluid (HTF). The most important application of solar energy is to transfer its thermal energy and then to electricity. Solar thermal power plant is one of the available applications of solar energy that its energy source depends on time, weather condition and electricity demand. Solar energy source of solar power plant is needed to be stored for smooth electric generation. The thermal storage system of the solar thermal power plant is necessary for the power plant stability and reducing rate of mismatch between energy demand and supply [1]. Basically, there are three methods of storing thermal energy: thermo-chemical, sensible and latent heat storage. For a thermo-chemical heat storage process, thermal energy is absorbed or released by breaking and reforming molecular bonds in a completely reversible chemical reaction. For a sensible heat storage unit, thermal energy is stored by changing the temperature of the storage medium which can be a solid or liquid [2]. The amount of energy stored in the unit depends on heat capacity of the medium, temperature changes and the amount of the storage material. The thermal energy may be stored as sensible heat. Sensible heat storage systems utilize the heat capacity and the change in temperature of the material during the process of charging or discharging temperature of the storage material rises when energy is absorbed and drops when energy is withdrawn. One of the most attractive features of sensible heat storage systems is that charging and discharging operations can be expected to be completely reversible for an unlimited number of cycles. For the utilization of solar energy or waste heat from industrial, the storage of the energy received is of particular interest and importance because of the intermittent nature of solar energy. The energy storage system in this case must be able to retain the energy absorbed for at least a few day in order to be able to supply energy as needed or on cloudy days when the energy input is small. For a small solar energy storage system, time period of the variation is one day. Therefore, the storage system must be designed with both the energy input and the demand as important considerations [3]. S. Somasundaram, et al. (1993) studied the integrate thermal energy storage in power plant, there are committed to used the oil-rock storage or molten nitrate salt storage which better than anothers storage [4]. T. Soontornchainacksaeng, et al. (1996) studied the water thermal energy storage system that play an important role for continuous utilization of non-permanent existing energy source such as solar heating system. Storage tank can be separated into 3 parts : 209 liter – thermal storage tank containing 184 liter of water, 30 cm-diameter charging coil made of 0.5 digit. copper tube and 30 cm-diameter discharging coil made of 0.5–inc. copper tube. The efficiency of thermal storage system while charging at all flow rates were nearly the same at 89% and the efficiency of the system while discharging at all flow rates were also the same of about 63% [5]. H. Michels and R. Pitz-Paal [6] studied the current revival of solar thermal electricity generating systems (SEGS) which unveiled the still existing need of economic thermal energy storages (TES) for the temperature range from 250 °C to 500 °C. The TES-benchmark for parabolic trough power plants is the direct two tank storage, as it was used at the SEGS I plant near Barstow (USA). With the introduction of expensive synthetic heat transfer oil, it capable to increase the operating temperature from former 300 °C up to 400 °C, the direct storage technology became uneconomical. Cascaded latent heat storages (CLHS) are one possible TES alternative, which are marked by a minimum of necessary storage material. The use of a cascade of multiple phase change materials (PCM) shall ensure the optimal utilization of the storage material [6].

A spiral heat exchanger, commonly used in stainless steel, seems to be a very good candidate for this task. Compactness, it enhanced heat transfer due to centrifugal forces, easy sealing, large heat transfer surface and a shorter undisturbed flow length are the most appealing features of such a choice. To transform this device into a spiral thermal storage energy unit (STES), one of its two working fluids is substituted by a material that is capable of storing energy due to both the sensible [7]. However, the effective use of a spiral heat exchanger, in the case when a non-phase change materials (NPCM) replaces one of working fluids, it should be preceded by comprehensive experimental and theoretical analyses. The questions of the behavior of potentially useful NPCM and its performance, a thus designed, storage unit should be addressed.

Curvilinear spiral geometry has not yet been studied in the context of the heat storage energy systems. Indeed, so far the classical double-pipe or shell-and-tube heat exchangers have been applied in the storage energy systems and a relevant theoretical and experimental analysis of the phase-change phenomenon has been restricted to geometry of a cylindrical capsule [8], an annulus gap, spherical or rectangular enclosures [9]. It was found that under the same experimental condition, unconstrained melting inside the sphere seems to occur at a faster rate than the constrained melting. This is due to the larger rate of heat transfer by conduction from the solid PCM to the spherical glass. Experimental and numerical analyses of melting of PCM inside a plexiglass spherical container was conducted by Felix et al. [10], where paraffin wax was used as the PCM. Investigation on the effect of the sphere radius, Stefan number, molten fraction and time for complete melting was carried out. The results for both the experimental and numerical were quite identical. It was found that Stefan number and the sphere radius had significant effects on the complete melting time of phase change material. The study of the constrained melting has been reported by Roy, S.K. and S. Sengupta, J.M. Khodadadi, Y.Z. [11, 12] and concluded that the conduction mode of heat transfer was dominant in the earlier stage of the melting process. At a later stage, the melting rate increased as the buoyancy-driven convection inside the liquid PCM became more significant.

Therefore, an experimental computerized stand has been constructed, where the one pipe stainless steel heat exchanger of spiral thermal distribution has been studied to determine overall characteristics of the temporal behavior of the NPCM and of the performance of the TES unit. The empirical findings were presented in terms of temperature changes of both media. Moreover, the thermal analysis of the storage energy unit is carried out where temporal energy stored, charging and discharging time, energy storage capacity, and energy efficiency of melted and solid phases of the storage medium were estimated.

Statement of the problem

Solar Thermal Power Plants (STPP) input is limited by diurnal, seasonal and climate changes. In order to cope with these fluctuations, STPP energy source may be backed up a buffering storage system.

The thermal energy storage system can be solved this problem by:

1. Stability

The storage is to smooth out transients in the solar input caused by passing clouds, which can significantly affect operation of a solar electric generating system plant. The efficiency of electrical production will degrade with intermittent insulation, largely because the turbine-generator will frequently operate at partial load and in a transient mode. If regular and substantial cloudiness occurs over a short period, turbine steam conditions and/or flow can degrade enough to force turbine trips if there is no supplementary thermal source to "ride through" the disturbance. Buffer TES systems would typically require small storage capacities.

2. Energy management

The storage is delivery period displacement requires the use of a larger storage capacity. The storage shifts some or all of the energy collected during periods with sunshine to a later period with higher electricity demand or tariffs (electricity tariffs can be a function of hour of the day, day of the week, and the season). This type of TES does not necessarily increase either the solar fraction or the required collection area. The typical size ranges from 3 to 6 hours of full load operation. The size of a TES for delivery period extension will be of similar size (3 to 12 hours of full load). However, the purpose is to extend the period of power plant operation with solar energy.

3. Suitable storage media

Definitive selection of storage capacity is site- and system-dependent. Therefore, detailed statistical analysis of system electrical demand and weather patterns at a given site, along with a comprehensive economic tradeoff analysis, are desirable in a feasibility study to select the best storage capacity for a specific application.

Objectives

1. To determine temperature profile of non-phase change materials (NPCM) for solar thermal energy storage.

2. To determine the thermal distribution performance of a storage system which NPCM as a solid storage media.

3. To calculation a performance of heat transfer in NPCM for solid media of a storage system.

Scope of the study

1. This study is limited by the system parameters of STE; use synthetic oil as heat transfer in the absorber pipes and the temperature of the synthetic oil to be consistence. The thermal energy is transferred to the turbine cycle at temperature between 25 °C and 250 °C.

2. Determine temperature profile of medium for thermal storage of NPCM such as sodium chloride, sodium nitrate and potassium chloride by comparison calculation and experiments.

3. The thermal distribution performance testing are temperature profile, storage temperature, charge, discharge, energy stored, energy recovered, energy efficiency with time by heat transfer fluid flow.

Benefits of the study

1. Calculation of thermal distribution and thermal storage energy of NPCM in solid sensible storage.

2. The temperature profile of NPCM was thermal storage energy.

3. The thermal property of NPCM affect on thermal performance.