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Applications of PCMs and Solar Energy for Greenhouse Heating

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Abstract—*One of the renewable source of energy is solar energy therefore using of solar energy for heating greenhouse were studied in this research. Greenhouse cultures are the major energy users in agriculture sector and demands of energy especially fossil fuels and fertilizer are increased in them. Several renewable energy sources have been used to replace a part of fossil fuels in recent years. Different solar heating systems have been also proposed. Due to this kind of energy source is nonpermanent and time dependent, energy storage systems must be used. There are different methods for storing solar energy such as convert to electricity by solar panels and stored in battery or used in solar pump for pumping water and storing water in tank above the earth and used mechanical energy of stored water in tank and etc. In this research between different methods, thermal energy storage was selected and for improving its performance, Phase change materials, PCMs, with 45-55 °C melting point and 200 kJ/kg latent heat capacity that capsulated with cupper tubes were used inside storage tank. After that, performances of the system were evaluated in three thermal initial conditions which were low temperature (30-35°C), medium temperature (42-47°C) and high temperature (54-59°C). The results showed that the mean decrease in temperature has been faster in the tank with a higher initial temperature than the temperature of the lower reservoir, but with proper volume and insulation and use of materials, particularly in the melted point range, changing of the temperature in the tank remains constant and the cooling process is slower..*

1. INTRODUCTION

The trend of energy consumption in Iran greenhouses showed that in recent years, energy consumption, especially of fossil fuels and fertilizers that the fossil energy used in their production has increased significantly. Most of the energy consumed is for heating of greenhouses. There were different method for improving energy consumption in greenhouse. One of them is energy storage system. Using the properties of latent heat storage materials due to the higher energy capacity is considered.

Jurinak and Abdel khalik [1-2] studied the effects of Phase-change material on the performance of solar heating systems. Their main finding was that the melting point of the phase change material has a significant effect on the efficiency of the system, so the melting point of the phase change material is more important than the amount of latent heat. Nishina and Takakura [3] for improving the performance of PCMs, a series of additives were added to them and used for heating of greenhouses equipped with flat plate solar collector used in Japan. They reported that although the temperature inside the greenhouse at night around 8 ° C, respectively, but only 60-40% of potential latent heat of the phase change material has been released. A series of theoretical and practical studies for determining the efficiency of the water outlet temperature with PCM were done by Kaygusuz [4]. The system consists of flat plate solar collector, energy storage tank, a water-air heat exchanger, electric auxiliary heating systems, pumps and equipment was measured. His tank of water and the phase change material with a melting point of 25 ° C was used. The investigation concluded that the energy storage system is essential for temperate climates. Fath [5] used energy storage systems in a flat plate solar heating systems. The phase change material is poured into a metal tube as the heat absorber was placed in the collector. Paraffin with a melting point of 50 ° C and a heat of fusion of 190 kJ kg was used as the phase change material. He reported that the efficiency of the system is 63% while in normal mode system efficiency was 38%. Kurklu et al. [6] evaluated two different melting temperature of paraffin with a melting range of 25-22° C and a melting point of about 8° C in a greenhouse. The first is to reduce greenhouse maximum temperature in summer and winter were used to prevent frost. The results showed that with proper selection of paraffin melting point can be controlled greenhouse climate. Mehmet [7] also use the Phase-change material in a solar heating system for heating air flat screen studied. He concluded that for effective heating pipes should be shorter and narrower. Vakilatojjar and Saman [8] developed a computer model to evaluate the thermal energy storage system for heating and cooling the environment. They concluded in their study to achieve better efficiency should be smaller and narrower containers used for paraffin embedding. Disadvantage of this method is to increase the number of containers for paraffin embedded systems will increase costs. Arkar and Medved [9] designed a solar ventilation system in which the phase change materials were used. They use paraffin poured into metal capsules were appropriate. Kurklu et al [10] tested a hybrid method. Their Solar System consists of two parts: one part was filled with water and the other with paraffin. The results showed that the intensity of radiation on normal water temperature to 55 ° C, 30°C overnight went up and stayed. Tiwari et al [12] reported a water saving tank with phase change material. They could successfully save energy and used it in the night. The results of previous research on the use of phase change materials for energy storage systems in greenhouses show the applicability and effectiveness of this material. Especially in the solid phase to the liquid. But the complex process of preparing some of their high prices on the one hand and on the other hand will be limited to industrial use.

2. MATERIALS AND METHODS

The storage tank was built to store heat energy in a solar heating system. The amount of heat storage tank heat loss at night from Formula 1 was used. As the formula shows the tracks to be added to the tank temperature and energy harvesting energy concentrators and losses depend on consumer [11]:

$$T_{+s} = T_s + [\, Q_u - L_s - (U\,A_0)_s (T_s - T_0)].\triangle t \,/\, (\, m.\, C_p)_s$$

The total thermal resistance between the outer surface of the pipe and fluid Rt is equal to:

$$R_t = R_{cond} + R_{conv} = 1/[2\pi.K] \times \ln(r_o/r_i) + 1/(2\pi r_o h)$$

Rt is the minimum amount of time dRt / dro = 0, in which case the maximum heat transfer from the tube.

$$dR_t/dr_o = 1/(2\pi K) \times 1/r_o - 1/(2\pi r_o 2h) = 0 \text{ so } r_o = K/h$$

In $r_o = r_c$ waste heat from the pipe will be maximum, therefore, $r_c = K / h$ is called the critical radius. The critical radius should be kept small by using insulation, to thermal energy loss is minimal

After the initial assessment insulated tank in the lab and get the desired results in maintaining the water temperature, the water temperature in the tank insulation with paraffin in the temperature range of 35-30, 47-42 and 59-54 degrees Celsius high and in an environment with a temperature of 17°C was monitored. For this purpose, a four-channel thermometer-type ST-3891G is equipped with a data recording system was used.

3. RESULTS AND DISCUSSION

Due to the curved surface of the tank critical radius of insulation as used. Using the formula for the critical radius it was 0.048m. Due to the critical radius is much smaller than the radius of the tank. So add any value to the tank insulation to reduce heat losses are in this study, the insulation thickness of 25 mm was used.

After the initial assessment of the tank and insulation in the laboratory and in maintaining the water temperature to obtain the desired results, the water temperature in the tank insulation with PCMs in the low temperature range 35-30, average temperature of 47-42 and high temperature of 59 -54 ° C in an environment with a temperature of 17 ° C within 11:00 to 11:00 the tomorrow day (Figure1, 2 and 3).

Investigate changes in water temperature in the tank is generally simple, Insulated and insulated with PCMs showed that a simple tank cooling rate was about 0.52°C per hour to about 0.21°C using insulation on reduced hours. The use of paraffin tank insulated cooling rate has to 0.16° C per hour.

Investigate changes in water temperature reservoirs with different temperatures revealed showed that the rate of heat loss is higher in tanks with high temperatures; For example, the mean decrease in temperature with the first temperature 59.5°C in an insulated tank tested 0.26°C per hour. The tank is insulated with respect to the initial temperature of 34.6 to 0.16 degrees Celsius per hour, cooled faster.

4. ACKNOWLEDGEMENTS

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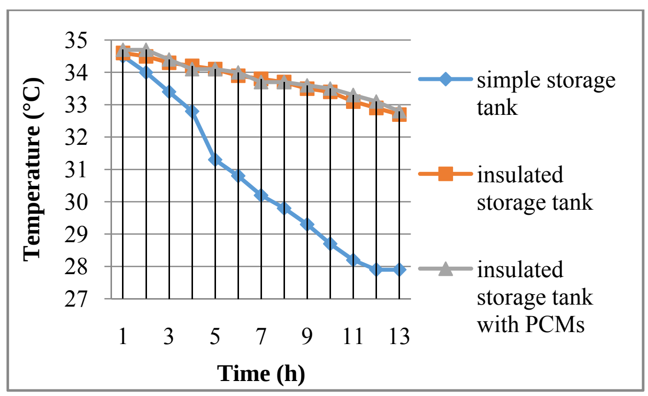

Fig. 1: Temperature changes recorded in various vessels with initial temperature 30-35 ° C

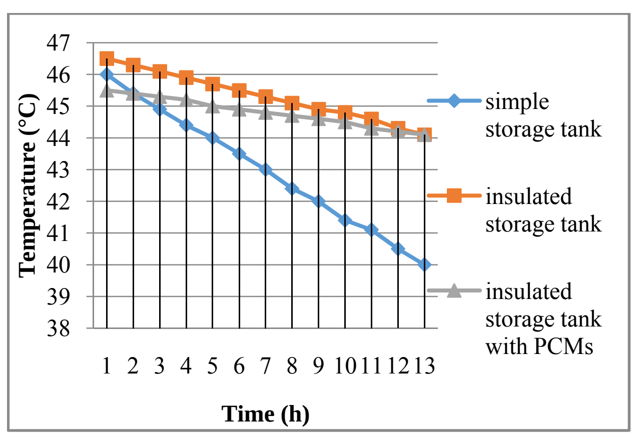

Fig. 2: Temperature changes recorded in various vessels with initial temperature 38-48 ° C

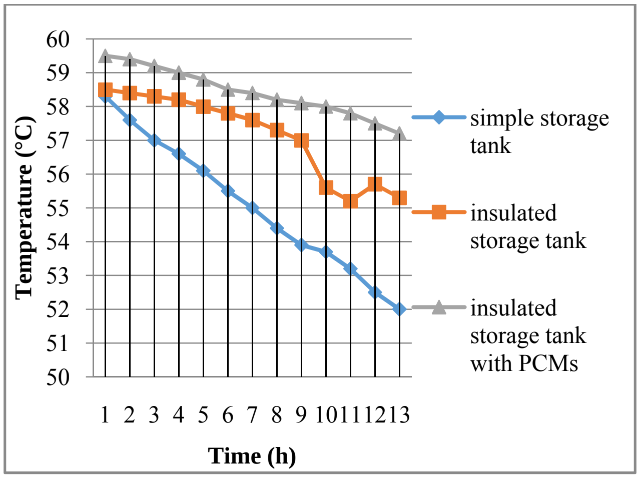

Fig. 3: Temperature changes recorded in various vessels with initial temperature 50-62 ° C

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