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Investigation of Thermal Performance Integrated Collector-Storage Solar Water Heater with Different Reflectors

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ABSTRACT

In this study, a type of Integrated Collector Storage (ICS) solar system is constructed and experimental tests are performed. The ICS system is a type of solar water heater with simple construction. In ICS, the storage tank is used for both water heating and storage, and there is no separate collector. Therefore, a larger storage tank is used which is subjected to direct solar radiation. In the present studies, the experimental model was investigated with three different reflectors. The results showed that the system has the lowest thermal efficiency with an aluminum foil reflector.

KEYWORDS

Solar Water Heaters, Integrated Collector Storage Systems, Compound Parabolic Concentrators, Thermal Performance.

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1- INTRODUCTION

The main types of Domestic Hot Water (DHW) solar systems that can cover the needs of about 100–200L of hot water per day are the Flat Plate Thermosiphonic Units (FPTU) and the Integrated Collector-Storage (ICS) systems. The profit in efficient heat preservation of hot water storage of thermosiphonic systems has resulted in their widespread application. ICS systems are applied less to solar water heaters because of higher thermal losses of storage tanks during the night, although they are cheaper and more aesthetically attractive than the FPTU in building integration. Thermal protection of water storage tanks of ICS systems is not efficient enough, as the total, or a significant part of the external surface of it is used for the absorption of solar radiation. Thermal performance of ICS systems during both the day and night depends on the design principles and the used materials, as well as the weather conditions. [1-4]

As an Integrated Collector Storage (ICS) solar system is constructed, the main purpose of this paper is to investigate the thermal performance of this system with different reflectors.

2- METHODOLOGY

A type of ICS was designed and constructed in Kerman, Iran. Its performance was investigated using its measured data. The main objective of the present research was to investigate the effect of different reflectors on the solar energy absorbed by ICS. Aluminum foil, mirror and highly polished steel plates were used as collector materials. In another part of this research, thermal performance of ICS was studied for different months in Kerman.

For the calculation of the mean daily efficiency η_d of each system we used the following formula:

$$\eta_d = Q_W / Q_R$$

The water mass $M_W(kg)$, the specific heat $C_{P,W}(J.kg^{-1}.K^{-1})$ and the initial $T_{i,m}(^{\bullet}C)$ and final $T_{f,m}(^{\bullet}C)$ mean water temperatures determine the heat quantity $Q_W(j)$, which is taken by the water without any heat removal during the day and is given by the following equation:

$$Q_W = M_W C_{P,W}(T_{f,m} - T_{i,m})$$

The total solar radiation intercepted by the aperture surface $A_a(m^2)$ of the system during the interval $\Delta t(s)$ from the start point t_i (7:00) in the morning to the final point t_f (19:00) in the afternoon is given by the parameter $Q_R(j)$, which is determined by the integration of the solar radiation intensity $G(t)$:

$$Q_R = A_a \int_{t_i}^{t_f} G(t)dt$$

3- RESULTS

The location of this experiment was in Kerman (Lon. 57.1 and Lat. 30.3 Degrees). Thermal efficiency of the system is measured by variation of the water temperature in the storage tank, regarding the ambient temperature and the incoming solar radiation. The three-day recording of the water temperature in storage tank is helpful for the estimation of its performance. Fig. 3 shows temperature changes during the experiment.

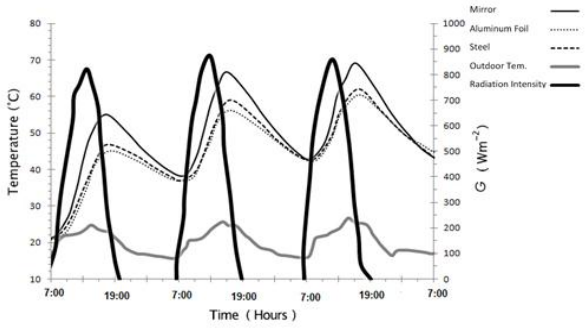

Fig.1. Temperature changes during 3 days of the experiment

As shown in Fig. 2, we can calculate the mean efficiency of the system regarding the above equations.

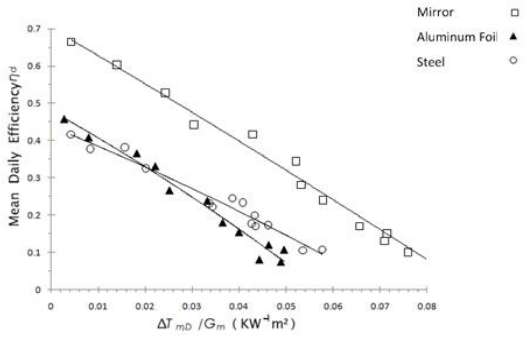

Fig.2. Daily mean efficiency

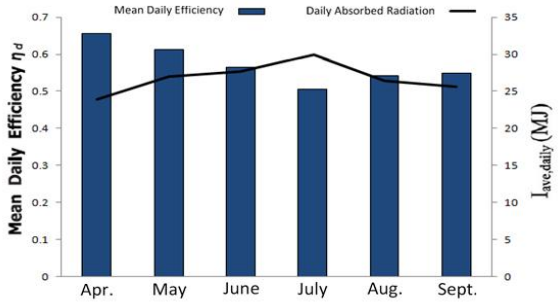

Fig.3. Efficiency of the instrument during months

4- CONCLUSIONS

In this paper, design principles and the construction details of an ICS solar system are presented. Thermal performance of this system is investigated with different reflectors, mirror, aluminum foil, and polished steel. Results showed that ICS with aluminum foil reflector has the lowest thermal efficiency while it also has lower heat loss at night. In another part of this research, the thermal performance of ICS was studied for different months in Kerman. Lower thermal efficiency was obtained for the months around July in Kerman with higher solar radiation.

5- REFERENCES

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