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Design and Development of Heat Exchanger for Solar Water Heater (SWH) Using Zeolite

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Abstract:- The objective is to find out the problems faced by the users while using solar water heater. This analysis and findings of the study reveals that solar water heater not working properly in rainy and winter season, this problem is faced by the maximum number of the users. Our work is to minimize the defect of the energy storage in the SWH system. Heat energy it can be stored at normal sunny time. The stored heat energy can be used in the absence of the solar ways. In this proposed work design and fabrication shell and tube type heat exchanger has been go through. Zeolite adsorbent particles are packed into heat exchanger shell. Adsorption and desorption process are controlled by atmospheric pressure, and heat generation due to the adsorption process and desorption of the heat are exchanged to the moving fluid in heat transfer tubes. Here, the maximum utilization of the thermal conductivities of the loaded bed heat exchanged from high temperature zeolite medium to low temperature flowing fluid medium. Thus, the heat transfer rate has to be improved in a effective manner, by means of shell and tube heat exchangers. Therefore, the system heat transfer rate is increased so that energy storage capacity to solve this problem.

Keywords:- *Solar water heater, Heat exchanger, Zeolite.*

I. INTRODUCTION

Usage of sun oriented vitality gives a correct method to decrease the utilization of non-renewable energy sources and worry of natural contamination. Current vitality approaches focus on both an expansion in energy effectiveness and an expanding replacement of non-renewable energy sources by renewable source of energy. However, to a great extent discontinuous nature is required for capacity innovations to associate the gap between time interim of high vitality prodution and high vitality utilization. Vishal G. Shelke. [1] The sunlight based energy is the most fit for the elective vitality sources. Because of rising interest for vitality and expanding cost of fossile energizes type (i.e., gas or oil) solar powered vitality is consider a great wellspring of sustainable power source that can be utilized for water hearing in both industry and homes. Sun oriented vitality is the vitality which is originating from the sun powered radiations in limitless sum, when the sun based radiations felt through the engrossing surface, at that point they gets changed into the heat, this heat is used for warming the water. M. Mani Bharathi. [2] This paper presents the Design and manufacture of shell and tube Heat exchanger with powerful way. Sandeep Kumar Dehariya. [3] The primary target of the investigation is to consider a low cost and viable solar water heater. The primary work is focussed on the expanding the exhibition and effectiveness of the SWH. Shoma Fujii et al. [4] introduced the presentation of Flat plate water heater and zeolite material vitality stockpiling limit with effective way. Christoph Lehmann et al. [5] Heat stockpiling techniques are qualified of performing number of methods: they can give stockpiling range just as improve the vitality effectiveness of modern procedures, e.g., by utilizing waste heat. Adsorption-based system speak to conceivable approach to putting away warmth. Also, they can be utilized for heat change. [6,7] introduced the vitality stockpiling thickness of the zeolite material and furthermore get the trial information. P. Rhushi Prasad et al. B.Guruprasad et al. [8] The goal of this paper is to examination the exhibition of the sun oriented water heater.[9] In this current investigation of flat plate authority and execution with following gatherer. A financially accessible flat plate water heater limit of 100 liters/day is instrumented and formed into a test-apparatus to lead the test work. Investigations were led for an environmental conditions were pretty much uniform and information was gathered both for followed and fixed states of the level plate gatherer. The outcomes show that there is a normal of 40^0c in the outlet temperature. The productivity of both the conditions was determined and the comparison says that there is an expansion of about 21% in the level of effectiveness.

II. METHODOLOGY

The zeolite has selected from the above studied material. To fabricate the heat exchanger and connected through the solar water heater system .The mass flow rates of water utilized to analyze the heat storage capacity of the system.

A. Thermal Energy Execution

The condition of mass stream pace of air is communicated by

$$\dot{m} = \rho A_{mod} v \qquad (1)$$

$$A_{mod} = L_1 L_2 \qquad (2)$$

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Where , L1 and L2 are the length of collector module and the width of collector module ,respectively.

$$Q_u = m C_p (T_o - T_i) \tag{3}$$

$$\eta_{TH} = \frac{m C_p (T_o - T_i)}{A_{mod} G} \tag{4}$$

III. EXPERIMENTAL DESCRIPTION

The experimental system was design , fabricated and tried in ACGCET karaikudi. The flat plate collector setup be made up of absorber plate, transparent cover, insulation material, frame, an water flowing pipeline and toughened glass. The water channel was sealed fully to avoid hot water leakage. Photo energy or solar energy Passing through the glazing surface was absorbed by absorber bed. Then the heat will be transfer to the water flowing pipelines.

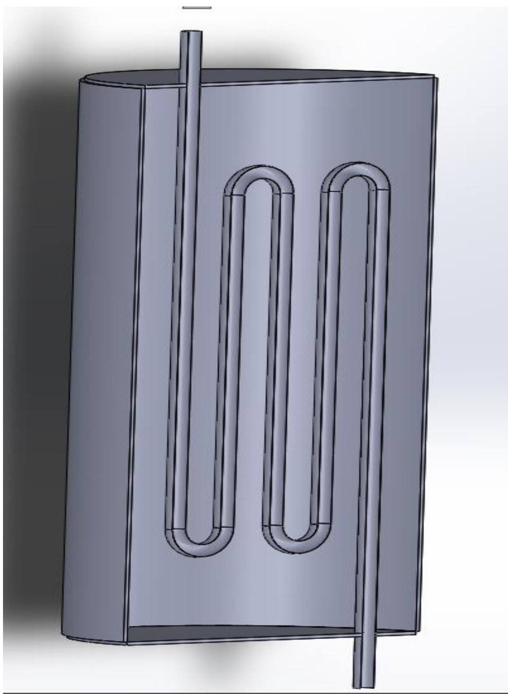

Fig 1:- heat exchanger model diagram using solid works

Experiments are conducted between Jan - mar 2020 at ACGCET karaikudi. All tests are starts at 9 am and finish at 4 pm on experimental days.

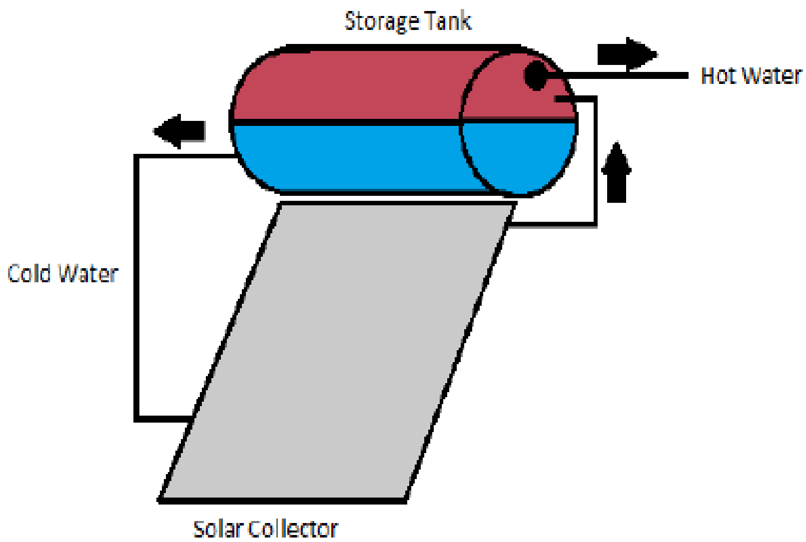

Fig 2:- Model view of solar water Heater setup

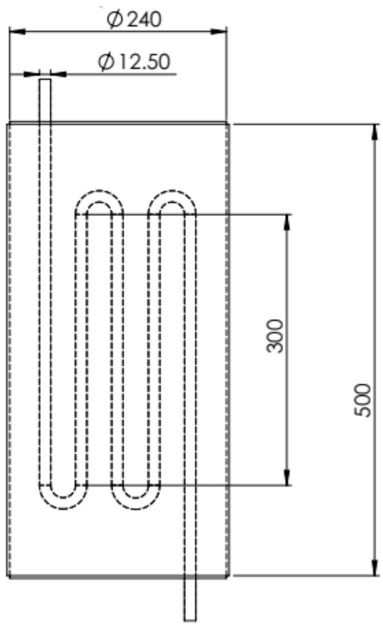

Fig 3

Components	Diameter	Height	Surface Area
1) Heat exchanger external dimension	240 mm	500 mm	$4.67*10^5$ mm^2
2) copper tube	12.5 mm	1600 mm	$1.27*10^5$ mm^2

Table 1:- shell and tube heat exchanger dimensions

Setup parameters	
Flat plate collector length, L	2 m
Flat plate collector breadth, B	1 m
Flat plate collector depth, H	0.085 m
Panel area, A	2 ^{m2}
Angle of the solar panel surface	14^0
Operating parameters	
ambient temperature (Ta)	307 – 345 K
Water entry velocity of the channel	0.4 - 0.6 m/s
solar radiation zeolite weight	400 - 1100 W/m^2 10 – 20 kg

Table 2:- Specifications of solar water heater setup.

IV. RESULT AND DISCUSSION

The solar water heater system execution tests were directed on exploratory day with clear sun condition. Model of solar water heater setup is appeared in Fig. 1. Heat exchanger model were inserted into the solar water heater setup that namely model along with its dimensions are revealed in Fig. 2.The shell and tube heat exchanger Dimension were appeared in table 1. Specification of solar water heater system were appeared in table 2.Three varies mass flow rates of water have been carried out in this study such as 0.005 Kg/s,0.01 Kg/s and 0.015 Kg/s.

A. Thermal proficiency and outlet water temperature

Thermal efficiency (η_{th}) was determined based on measurement such as difference in outlet and inlet water temperature (ΔT),mass flow rate of water (m), specific heat of water (C_p), area of the solar panel (A_{mod}) and solar radiation(G). The thermal performance improved with increase in water flow rate from 0.005kg/s to 0.015Kg/s. The thermal performance of water channel with heat exchanger and zeolite material better than without heat exchanger and zeolite material. The turbulence which was created with the use of heat exchanger is resulted in distribution of water at all the corners of the heat exchanger. The outer side extracted more heat energy which generated best performance of the setup. The hourly variations of thermal energy Vs outlet water temperature for heat exchangers of the solar water heater module were calculated by equation 1-4. Evidently, outlet water temperature was maximum between 11Am to 2Pm for heat exchanger. It was because of most extreme sun based radiation greatest accessible those hrs. solar radiation and thermal efficiency were directly linked with one another. However, a difference of outlet and inlet water temperature of the model considerably enhanced the thermal efficiency. The experimental conducted results of solar radiation from 11.00Am – 1.00Am hours have been increased remarkably which reflects the better thermal efficiency of heat exchanger. Whereas, experimental results of solar radiation at 9.00Am and 4.00 Pm were normally less that revealed low thermal efficiency. Sunlight based radiation was an essential power to actuate thermal effectiveness which remove more heat vitality from the sun oriented water heater.

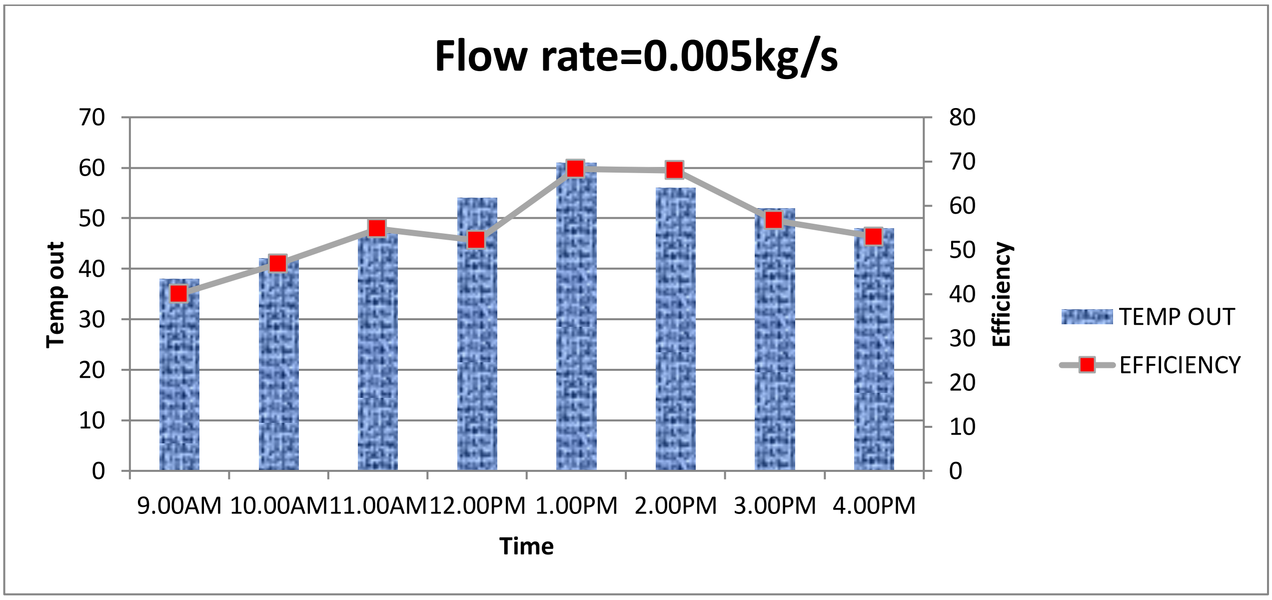

Fig 4:- Test day for mass flow rate of 0.005kg/s (vs) Thermal efficiency and outlet water temperature

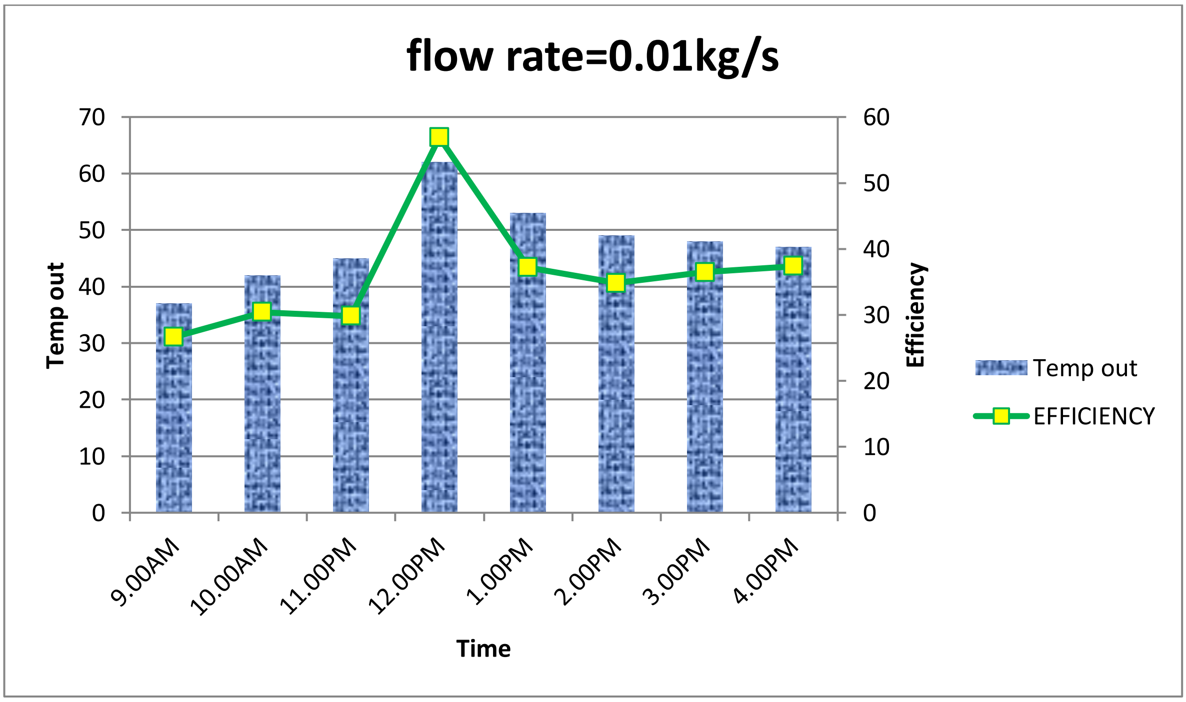

Fig 5:- Mass flow rate of 0.01kg/s (vs) Thermal efficiency and outlet water temperature

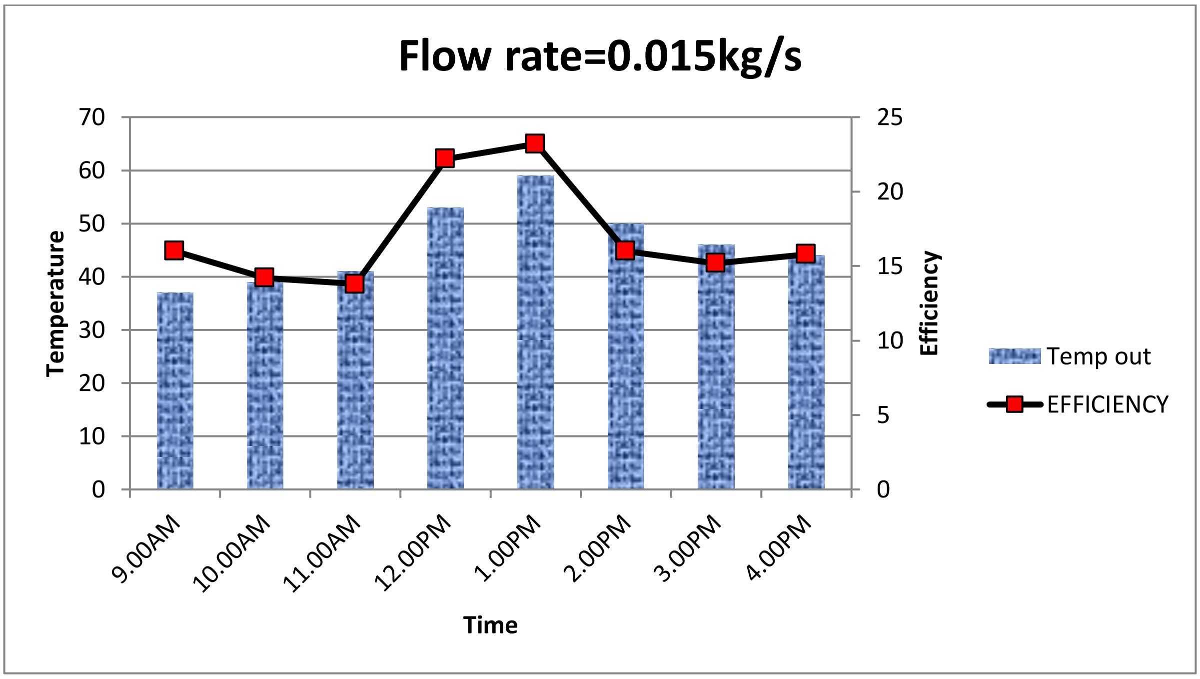

Fig 6:- Mass flow rate 0.15kg/s (vs) Thermal proficiency and outlet water temperature

Outlet water temperature and hourly variation of thermal efficiency for mass flow rates of 0.005kg/s , 0.01 kg/s and 0.015kg/s are shown in fig 4,5 and 6. The heat exchanger, contained transverse heat exchanger with zeolite material on its absorber bed. The thermal efficiency of SWH was seen as 65 % for mass flow rate of 0.005kg/s.

V. CONCLUSION

In this present exploratory examination, heat exchanger were used in the SWH system and critical conclusions on execution were drawn as given below.

- The experimental execution was significantly higher, upgraded heat moves and change in outlet and inlet water temperature contrast at mass flow rate 0.005 kg/s ,0.01 kg/s and 0.015 kg/s.
- The execution of the solar water heater setup has been upgraded with the mass flow rate between 0.005 kg/s and 0.015 kg/s.

Nomenclature	
A_{mod}	area of the solar module (m^2)
C_p	specific heat of air (kJ/kg K)
G	solar radiation (W/m^2)
$\dot{m}$	Mass flow rate of water(kg/s)
Q_u	useful heat (W)
T_i	inlet temperature(^0C)
T_o	outlet temperature(^0C)
v	velocity of water (m/s)
Greek letters	
ρ	density (kg/m^3)
η_{th}	thermal efficiency (%)

Table 3

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