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Experimental Investigation of Storage Tank Design on the Performance of a Solar Water Heating System: Review Approach

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Abstract— Solar energy is easily available in nature, pollute less, priceless and therefore it is accepted as one of the most capable unconventional energy sources. The effective use of solar energy is held up by the intermittent nature of its availability, limiting its use and success in domestic and industrial applications especially in water heating. This topic is about to investigation and optimization of solar water heating system by varying zig-zag tube arrangement with natural convection. By using zig-zag tube arrangement in the solar water heating system the efficiency will slightly increase. The aim of the research work is to improve the performance of solar water heater by changing the tubes geometry and material of tube. The purpose of this study is to improve the technology available for solar water heater. It is mature technology still it has many opportunities for modifications. Further research work is required in the field of cost and performance of collector plates and glazing cover plates.

Keywords—Solar Radiation Intensity, Tube Geometry, Tube Material, Type of Flat Plate Collector used.

I. INTRODUCTION

Solar energy is a sustainable source of energy and environment friendly. According to over 14 years of span report on annual basis from 2000 to 2014 of National Renewable Energy Laboratory USA (NREL), in most of the India, direct solar irradiation intensity is about 4 kWh/m^2/day to 5 kWh/m^2/day. But solar water heating technologies are costlier than regular electrical water heating system. Technology improvement efforts for solar water heater should focus on maintaining the performance and reliability of current solar water heater systems and reducing total system installation costs. Recent analysis led to identification of technology improvement opportunities to overcome barriers related to cost, performance, operation and maintenance, and reliability. According to K.Hudon [1] , there are many opportunities in field of glazing cover plates and absorber plates in collector designing.

II. SOLAR WATER HEATING SYSTEM

Solar water heaters use solar radiations from sun to heat water. Solar collectors absorb radiations and transfers it to water.

Most residential solar water heating system consists of basically five components:

i. Solar thermal collector – flat-plate and evacuated tube collectors are the most typical.
ii. Storage system – they are used to meet the thermal energy demand when solar radiation is not available.
iii. Heat transfer system – piping and valves for liquids; pumps, fans, and heat exchangers (HXs), if necessary.
iv. Control system – They are used to manage the collection, storage, and distribution of thermal energy.
v. Auxiliary storage tank – to provide supplemental heat when solar energy is not sufficient to meet demand. This is typically a conventional electric resistance or natural gas storage tank water heater.

2.0 SOLAR COLLECTOR

Solar collector or solar thermal collectors consist of following basic elements:

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2.1.1 Data Confidentiality:

Ensures that information content is never revealed to anyone who is not authorized to receive it. It can be divided (in secure data aggregation schemes) into a hop-by-hop basis and an end-to-end basis

2.1.2 Authentication:

There are two types of authentication; entity authentication, and data authentication. Entity authentication allows the receiver to verify if the message is sent by the claimed sender or not. Therefore, by applying authentication in the WSNs, an adversary will not be able to participate and inject data into the network unless it has valid authentication keys

2.1.3 Data Availability

Ensures that the network is alive and that data are accessible. It is highly recommended in the presence of compromised nodes to achieve network degradation by eliminating these bad nodes.

Aggregator rotation that rotates the aggregation duties between honest nodes to balance the energy consumption in WSN.

2.2 TYPES OF SOLAR COLLECTORS

Solar collector can be classified by many ways. On the basis of flat plate arrangement, it can be classified as:

i. Lower bounded tube collector: Tubes are bounded below the plates.
ii. Upper bounded tube collector: Tubes are bounded above the plates.
iii. Tube-in flat plat collector: Tubes are in between the plates.

2.3 EXPERIMENTAL SETUP FOR INVESTIGATION

The experimental setup contains some of the basic testing equipment like flowmeter, manometer, pyrheliometer or pyrometer and some thermocouples.

Pyrheliometer are used to measure direct solar radiation and pyrometer is used to measure direct as well as diffused solar intensity. Solar intensity depends on many angles like declination angle of sun, hour angles, tilts of plane from horizontal etc. It also depends on the intrusion of the clouds as in cloudy weather solar intensity can't incident on the earth surface. Generally, the value of the reflectivity is not known precisely for most of the situation, so it is required to use pyrheliometer or pyrometer.

Flowmeter is used to measure flow rate. It is required to know the pumping power and the velocity of fluid flow.

Manometer is used to measure total pressure loss during flowing in bents and do to heat transfer.

Thermocouples are used to measure the temperature at any local points. By using thermocouples, we are calculating inlet and outlet fluid temperature to the collector.

The setup shown in figure 4 is a closed loop consisting of the flat plate collector under test, a liquid pump, a heat exchanger and a storage tank with an electric immersion heater. A bypass is provided around the pump so that the mass flow rate can be adjusted to the prescribed value. The purpose of heat exchanger is to remove heat. Thus the combination of the heat exchanger and the storage tank provide a means for adjusting and controlling the inlet fluid temperature to the collector to a desired value. The standard specifies that the collector shall be tested under clear sky conditions in order to determine its efficiency characteristics. On any given day, data is recorded under steady state conditions for fixed mass flow rate and initial fluid temperature. For each set of fixed values, it is recommended that an equal number of tests be conducted symmetrically before and after solar nooThe principal measurements made in each data set are the fluid flow rate (m), fluid inlet (T_{fi}) and outlet (T_{fo}) temperature of the collector, the solar radiation incident on the collector plane (I), the ambient temperature (T_a), the
pressure drop across the collector (ΔP) and wind speed (T_∞). The efficiency is calculated from the equation:

III. RELATED WORK

K. Hudon, **[1] the author state that Identify** the target market for solar water heaters (SWHs) that will provide the largest U.S. energy savings potential relative to other advanced water heating technologies. • Identify potential technology pathways and cost/performance targets that must be met to enable SWH systems to achieve large energy savings**.**

Nosa Andrew Ogie [2] and T. H. Holland [3] explained designing and construction of a solar water heating system. They both explained method to design solar water heating system. According to T.H. Holland, efficiency of two covered flat plate collector is 4 percent higher than one covered flat plate collector for residential applications. Similar conclusion can be seen in the results of Nosa Andrew Ogie's procedure. Nosa Andrew Ogie published paper on design and construction of solar water heater based on thermosiphon principle. They conducted experiment on plate over tube type solar water heating system type collector. They concluded that the insolation increases from low value at 7:00AM got to a peak value between noon and 3:00PM and then fall back to low value. They also explained absorber coating material and its effects.

P. Shivkumar [4], conducted experiments on solar heating system for performance enhancement. He also conducted experiments on flat plate collector solar water heater. They used experimental setup with riser tubes with three different arranges as follow: 9 numbers riser tubes flat plate collector, 12 numbers riser tubes flat plate collector and Zig-Zag arrangement of riser tubes. The collector efficiency at 9.00 hour is 36.4% for 9 riser tubes, 39.2% for 12 riser tubes and 42.00% for zigzag arrangement system. The maximum efficiency is observed at the time 13.00 hour in all the three cases as 53.38%, 59.09%, and 62.90%, respectively. The collector efficiency decreases after 13.00 hour till 17.00 hour in the same manner. The graph reveals that the maximum efficiency is at 13.00 hour in all the three cases. Maximum efficiency is recorded for zigzag arrangement.

M.Z.H. Khan [5] , also conducted experiments in solar heating system for efficiency towards sustainable development. They conducted experiments on all the major three seasons. They used zigzag type solar water heating system for experiments. They concluded factors affecting the temperature of hot water. They are as follow: effect of exposure to sunlight, effect of DC heater and effect of

carbon powder. Shading in the collector affects the heating of water and the maximum temperature is found during 10:00AM to 1:00PM due to hot, shiny and acute warmness of weather for higher intensity of solar energy. 6V rechargeable battery is used as backup system to heat the system water. Due to use of carbon powder as coating layer in solar heater increase in outlet temperature can be recorded directly proportional to percentage carbon in coating layer.

H.I. Abu-Mulaweh [6], explained designing and development of solar water heating system experimental apparatus. Standardized testing procedure is required for comparing the efficiency of different type of collectors and designing and selection of right equipment. Indian Standard IS: 12933 (1992): part 5 by Bureau of Indian Standard (BIS) can be understand. This is similar to experimental standard given by American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). Operation and maintenance is explained in Indian Standards IS: 12976 (1990): Solar water heating systems- Code of practice [MED 4: Non-Conventional Energy Sources.

IV. FINDINGS OF LITERATURE REVIEW

Experiments were carried out to study the charging and discharging performance of storage tank with different position coil HX at different flow rate. The discharging efficiency and charging efficiency were introduced to evaluate the performance of discharging process and charging process. Annual simulation was also carried out to analyze the long-term performance of SWHS with different position coil HX.

The solar collector of flat-plate type in SWH systems is famous in the market because they possess simple designs and only require minimum maintenance [69]. Apart from being inexpensive to manufacture, other advantages of FPCs are their ability to accumulate both beam and diffuse radiations, and they need no sun-tracking due to their fixed-imposition design structure.

4.1 COOMPARISION OF ORGANIC AND IINORGANIC HEAT STORAGE FOR STORAGE TANK SYSTEM WTH HEAT EFFECTIVENESS

Organics	Inorganics
Merits: Chemical and thermal stability, High heat of fusion, Good thermal Suffer little or no supercoiling, conductivity, Cheap and Non-corrosives, Non-toxic, High non-flammable heat of fusion and low vapor	Chemical and thermal stability, High heat of fusion, Good thermal Suffer little or no supercoiling, conductivity, Cheap and Non-corrosives, Non-toxic, High non-flammable heat of fusion and low vapor
De-merits: Low thermal conductivity, High Phase decomposition and suffer changes in volumes on phase from loss of hydrate, lack of change, Inflammability, Lower thermal stability, Supercoiling, phase change enthalpy Corrosion	Low thermal conductivity, High Phase decomposition and suffer changes in volumes on phase from loss of hydrate, lack of change, Inflammability, Lower thermal stability, Supercoiling, phase change enthalpy Corrosion

4.2 ENERGY ANALYSIS: HEAT VARIATION OF SWHS. UNIT: MJ:

Heat	Bottom-coil SWHS	Middle-coil SWHS	Top-coil SWHS
Annual heat released	10499 10458	10458	10451
Annual coil heat exchanged	4591	3019	1646
Annual auxiliary heat	6301	7786	9130

The charging performance decreased with the rising of HX position in the tank, then led to lower annual performance lower solar fraction and lower collector efficiency.

V. COMPARISION FINDINGS

According to Nosa Andrew Ogie [2] , the thermal in-solation is highest during noon and due to that efficiency can be maximum during noon hours. It also means that difference between inlet fluid temperature and the surface temperature of collector is higher than the heat transfer will be higher. According to T. H. Holland [2] , two mirrored transparent cover is best for designing. If proper insulator materials are applied, then heat loss can be minimized.

According to P. Shivshankar [4] , rearrangement of tube and plates is possible can be useful in enhancement of fluid outlet temperature and efficiency of solar water heating system. And according to M.Z.H. Khan [5] , carbon powder usage over the tubes can further useful in increasing the tube surfaces temperature.

H.I. Abu-Mulaweh [6] gave a proper methodology to successfully conduct the experiment for solar water heating system.

Solar water heater is a mature technology, but the fact remains that solar water heaters are not cost effective against the current price of natural gas, as was previously identified as the target market for solar water heater technologies. Research and development (R&D) can lead to significant advances in materials, design, and manufacturability, which can contribute to lowering the cost of solar water heaters, improving their performance, and easing installation, both in new construction and in retrofit markets.

On the basis of all the above mentioned, there are many modifications are possible in case of solar water heating technologies. I am contributing in the serpent type solar water heating system. Plates of copper will be joined to tubes as tube-in flat plate type collector. It will increase the outlet temperature of the fluid and efficiency of the system. It may result in pressure drop but serpent type solar water heater is good for the residential utilizations. Insulated container will be made by mineral wool, rock wool or glass wool with aluminium foil cover. Heat gain rate per unit length can be increased by perfectly utilization of absorber plate. A proper setup can be implemented for the experiments as prescribed by BIS and ASHRAE. Using carbon powder is independent parameter so it may be applied.

VI. CONCLUSIONS AND FUTURE SCOPE

The main objective of the research work is Solar water heating system plays an important role in sustainable energy management in Indian households as well as worldwide. Such an effort will not only be useful in improving the quality of life but also in environmental protection. This review paper is focused on the past & current research of energy storage through various techniques for solar water heating systems. This paper will also help to find the suitable comparison findings of heating storage system and provide the various designs for solar water heating systems to store the solar thermal energy.

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