EXPERIMENTAL STUDY OF PARABOLIC TROUGH COLLECTOR SYSTEM FOR WATER HEATING

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Abstract : Now a day's Most of the power is generated using fossil fuels, which emissions of carbon dioxide and other pollution every second. More importantly, fossil fuel will eventually run out. To make the growth of our civilization, people are searching for clean sources of energy. This increasing demand in clean sources of energy, the solar energy is one of the greatest growing source in the market and there are many major ways for solar energy development. As the technology moves into commercialization, models become necessary to predict system behavior under various operating conditions. Solar Parabolic Dish is currently used for the Water heating and cooking applications.

This work presents practical platform based on the development and performance characteristics by **tracking** solar dish focused system. The system is made with highly focusing materials. The results will be taken on summer and cloud free days. The collector's performance would be determined.

Index Terms **- Solar Water heater, Parabolic Trough Collector, Reflective material, Solar Tracking.**

1. INTRODUCTION

One of the greatest challenges facing mankind in the twenty-first century is energy. Starting with the industrial revolution in the eighteenth century, fossil fuels like coal, natural gas, Diesel, Biogas and petroleum have been the main energy resources for everything vital for human society: from steam engines to Otto and diesel engines, from electricity to heating and cooling of buildings, from cooking and hot-water making, from lighting to various electric and electronic gadgets, as well as for most of the transportation means.

However, fossil fuel resources as stored solar energy accumulated during hundreds of Millions of years are being rapidly depleted by excessive exploration. In addition, the burning of fossil fuels has caused and is causing damage to the environment of Earth. It is understandable that alternative or renewable energy resources, other than fossil fuels, have been studied and utilized. Hydropower, a derivative of solar energy, currently supplies about 2% of the world's energy consumption. The technology has matured, and the available resources are already heavily explored. Wind energy, also a derivative of solar energy, is being utilized rapidly. The resource of such highly intermittent energy is also limited. Nuclear energy is not renewable. The mineral resource of uranium is limited. The problems of accident prevention and nuclear waste management are still unresolved. The most abundant energy resource available to human society is solar energy. At 4×10^{6} EJ/year, it is ten thousand times the energy consumption of the world in 2007 [1-5].

The global energy consumption in the last 50 years has increased drastically and will continue to do so for the next 50 years. With the increasing population of the world and the demanding increase for a higher standard of living, the energy requirements needed to sustain the world's needs are steadily increasing. The reserves of nonrenewable energy resources are shrinking; in order to avoid a worldwide energy crisis, renewable resources must be implemented in every application possible. Of the various renewable forms of energy, solar energy proves to be amongst the most diverse and effective renewable energies. One of the most successful applications of solar energy has been in the use of heating water.

India, with its tropical climate, can tap solar energy for heating water for domestic & industrial purposes & various non-heating purposes, like street lighting etc. The non- conventional water heating system based on solar energy has a major advantage in that, once the initial installation is carried out, the consumer will have minimum recurring expenditure.11% of the world's power is supplied by biomass, while 85% is derived from fossil fuels. For this reason, renewable energy resources must become more abundant in residential areas, such as solar thermal energy. The average solar power incident on the earth is approximately 1000W/m^2 or about 100,000 TW. This energy source is much greater than the current world power consumption of approximately 15 TW. Solar energy is abundant to everyone in the world; small steps must be taken to harness the power to fuel energy needs. Heating your water with solar energy can be a rewarding venture in more ways than one.

Energy Independence: Using solar energy can reduce your dependence upon the utility, as well as the fossil fuel companies that supply it. It helps reduce the nation's reliance on foreign energy sources. Solar is as reliable as getting your energy from the utility, as well. Many folks with solar hot water only need to use the utility for backup, and sometimes not even that. Independence can be a very gratifying experience.

Environmental Impact: In fact the most of our energy derived from fossil fuels. This causes a wide array of environmental issues, including human-caused climate change (Global Warming), acid rain, Deforestation, and health hazards around Thermal power plants. The use of nuclear energy and its long-lived, poisonous byproducts is an important issue to many.

Financial Benefits: When you choose to use solar to replace all or part of what you had been using the utility for, that comes with financial savings on your utility bill. Solar-electric, as popular as it is, does not have as high an energy and cash savings per amount spent as does solar water heating. It is easy to see 50% to 100% savings on your bill, helping systems to recoup the original investment in 5 years, and as little as 3 years. The time depends largely on your local solar resource and how much utility energy costs [6-9].

2. EXPERIMENTAL SETUP

Selection of Collector

After reviewing of all the above literature of different surveys, it is decided that a concentric solar Parabolic collector and It was constructed so that all the sun rays are reflected to a single line called as focal Line. This includes selection of material for reflecting the solar rays to the focal line and sticking the reflective material to parabolic collector.

Parabolic trough design

A modified design of parabolic trough collector developed was used for comparison in this work. Specifically, Concave mirrors are added to the trough in order to trap solar radiation reflected from the surface to reduce heat losses. The designs are shown in Figure. The HTF is filled in the collector tube and the temperature and duration of exposure are measured. The process will be repeated for several times for several days. One type of HTF are used in the experiment, which is water. With the introduction of the mirrors, the efficiency is expected to increase.

Components Used In Parabolic Trough Collector

1. Reflective Mirrors
2. Solar Tubes
3. Thermistor
4. Tracking System

Figure-1: shows the photograph of the experimental setup

Specifications

i. Base -180cm
ii. Height in left side-60cm
iii. Height in right side-90cm
iv. Length of the mirror -150cm
v. Radius of the mirror-60cm
vi. Tube length-180cm
vii. Focal Length-180cm

3. FOCAL POINT EVALUATION

The focal point length is one of the important criteria of a collector. Sometimes the focal point length is different from the theoretical value given by the manufacturer or supplier, had an impact on the predicted performances of optical system. Many methods developed to find with more or less accuracy a lens's focal point length. Out of which Some methods may be easily implemented, other methods requires more Raw material and analysis techniques with more or equal accurate measurements.

When the paraboloid is aimed at the sun, the light rays obtained from it are falls on its mirrored surface which are reflected on a point called as focus. If the cooking pot or bowl is placed on the focus it will absorb the light's rays (Heat Energy) and becomes very hot. Parabolic Solar heaters heats the things quickly and are used to cook, heat up or fry foods, boiling water or even produce electric power. They can also be used to generate steam through power sterling engines, produces H_2 gas. A paraboloid mirror revolves and will be used to concentrate the rays of the sun light at its focus, creating a heat source at FOCAL POINT.

Steps to calculate focal point:
The following equation is used to determine the focal point. The formula for a parabola is

$$\mathbf{F=D^2/16X \text{ (or) } F=R^2/4a} \text{ ---------(a)}$$

To find the focal point of a parabola, follow these steps:

Step 1: Measure the longest diameter (width) of the parabola at its rim.
Step 2: Divide the diameter by two to determine the radius (R) and square the result i.e.,(R^2).
Step 3: Measure the depth of the parabola (a) at its vertex and multiply it by 4 i.e.,(4a).
Step 4: Divide the answer from Step 2 by the answer to Step 3 ($R^2/4a$).

The answer is the distance from the vertex of the parabola to its focal point [11].

The point at which all elements or aspects converge; center of activity or attention; the central or principal point of focus.

Diameter of the reflecting mirror (D) = 60cm
Depth of mirror (X) = 30cm
Therefore the focal point $= D^2/16X$
$= 60^2/16(7.5)$
$= 3600/120$
$= 30$cm

4. RESULTS AND DISCUSSIONS

For each working fluid, the experiments were repeated seven times on different days to ensure consistency of data. Testing was done during the summer and clear sky with cloud free days during the month of April 2018 for about Five days. The tests were taken between 10 am to 4 pm in data were taken on each hour.

The results obtained after conducting the experiments were tabulated below and plots also drawn to show the variation.

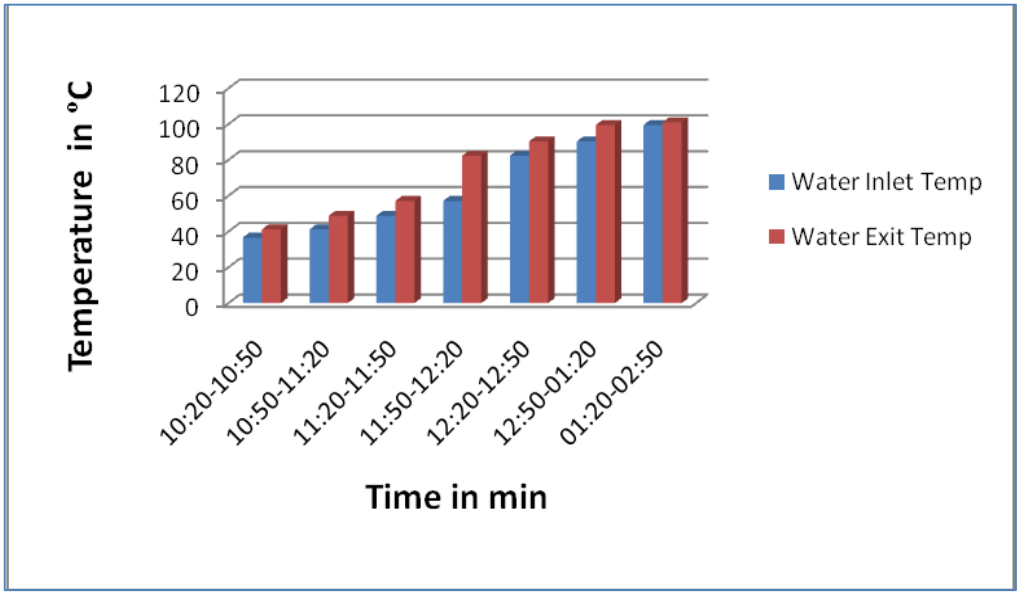

Figure-2: Variation of Temperature with time of the day 1

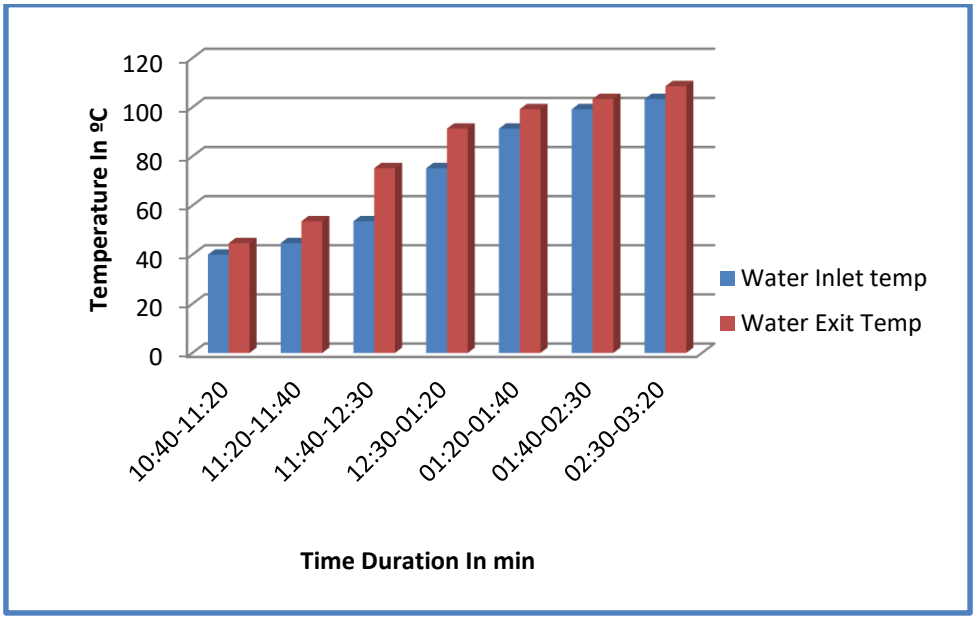

Figure 3 Variation of Temperature with time of the day 2

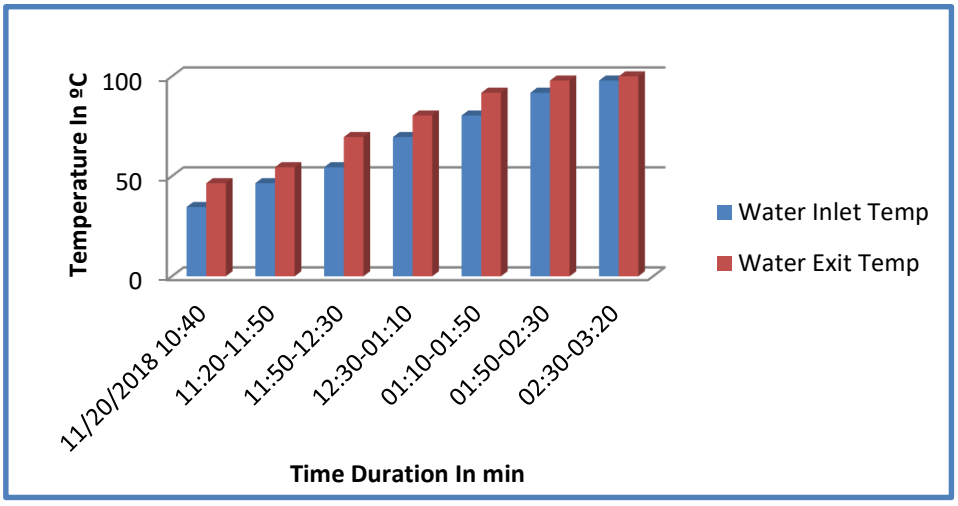

Figure 4 Variation of Temperature with time of the day 3

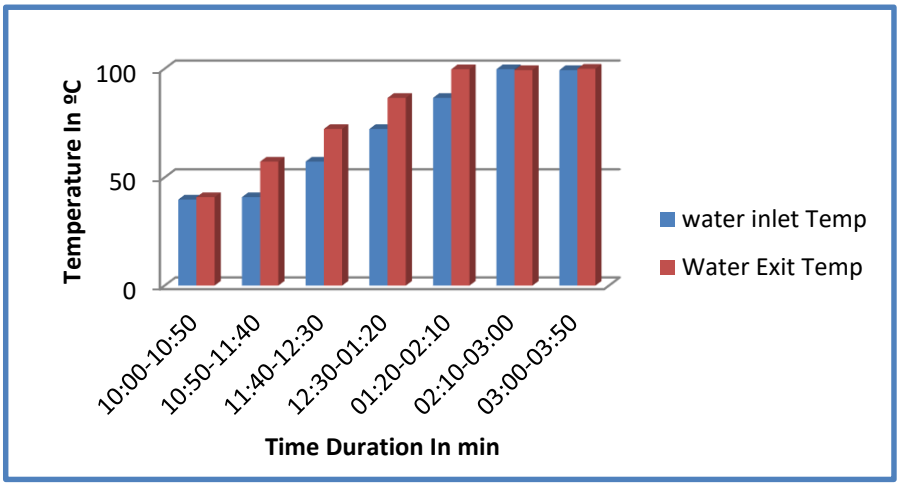

Figure 5 Variation of Temperature with time of the day 4

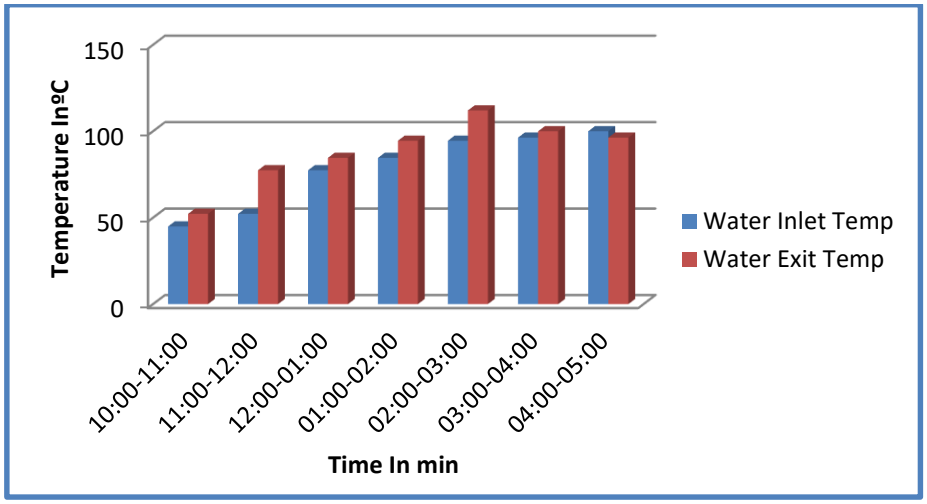

Figure-6: Variation of Temperature with time of the day 5

5. CONCLUSION

On the basis of the results obtained from the experimental study, the following conclusions can be drawn:

- The purpose of this project was to develop a low cost solar water heater. Specifically, a Parabolic concentric solar collector system and deliver a temperature of 100ºC
- Materials were selected based on cost, performance, and accessibility.
- The experiments, theoretical and analytical calculations have clearly shown the performance of PTC is satisfactory and used for commercial use in the industry. Parabolic trough Collector technology (PTC) is currently used as the most established concentrated technology for solar power generation.
- It can therefore be: Considered to be of relatively low technology risk, for smaller scale power generation or process steam applications, A large Numbers of projects are currently in development, reinforcing the technical viability of the technology.

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