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Solar Water Pasteurizer

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Abstract — *The limited availability of potable water is the major motivation behind our project and the aim is to cost efficiently convert the locally available water into relatively safe drinking water using locally available resources and also keep it in the economic reach of the masses using it. In order to achieve this goal the system design incorporated the Reflectors and the Heat Exchangers. The solar radiation shall be concentrated on the heat receiver using reflectors, heating incoming relatively impure water and converting it into the comparatively safe drinking water. Thus, it is based on the conversion of solar energy. And the instrument shall be available on an affordable basis.*

Keywords-component: Solar Energy, Radiation, Pasteurization, Potable water, Eco-Friendly

I. INTRODUCTION

The developing world is facing crisis of Potable water like never before most of these countries are located near the equator and thus they have access to solar energy. The people residing in these nations are facing economic losses due to health problems and the too many children facing absenteeism at schools. Also, child and miscarriage rates are very high in these regions. Thus, we felt that this problem can be solved by means of solar energy, as it is available in abundance.

The method we choose is ‘Water Pasteurization’ in order to reduce Pathogens in water to make it relatively safe for drinking purpose. Here no change is made to the chemical property of the water. Pasteurization of water is achieved about 50°C temperature.

This system consists of very simple component and it is made by keeping in mind the affordability and minimum running cost along with ease of maintenance. This system is designed to provide potable water to a nuclear family.

The component used here to achieve Pasteurization is ‘Food-Grade Heat Exchanger’. It is a copper tube of four (mm) millimeters used in refrigeration / Air Conditioning system which is wound in spiral shape and mounted over aluminum plate with matte black finish over the heat exchanger. The reason for making this tube is its readymade availability.

The rest of the system is comprised of readily available solar cooker which adds to its advantage that it becomes multi-utility instrument with minimum cost addition and there is ample manufacturer of solar cooker which makes this feasible.

II. SYSTEM COMPONENTS

- **Frame:-**

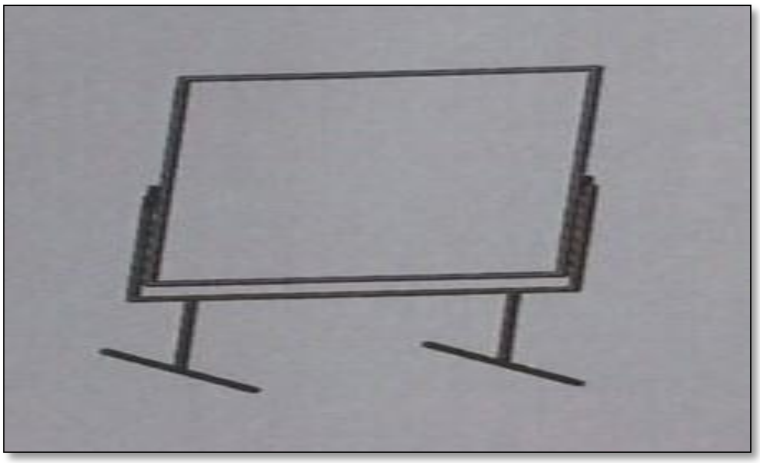

Figure 1. CAD Model of Frame

It is mild steel rods welded together into a structure. Here mirror is mounted whose aim is to reflect radiation coming from the sun.

- **Heat Exchanger:-**

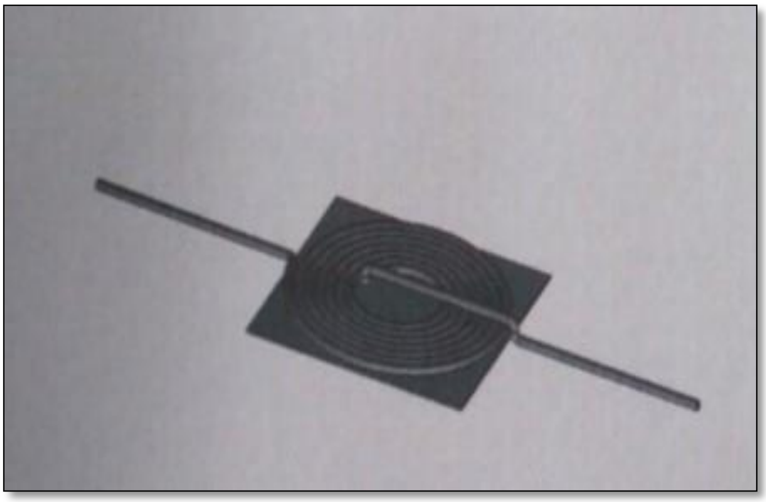

Figure 2. CAD Model of Heat Exchanger

It is CAD Model of Heat Exchanger comprises of Copper pipe mounted upon aluminum plate. The copper pipe is woven in spiral shape.

- **Solar Cooker:-**

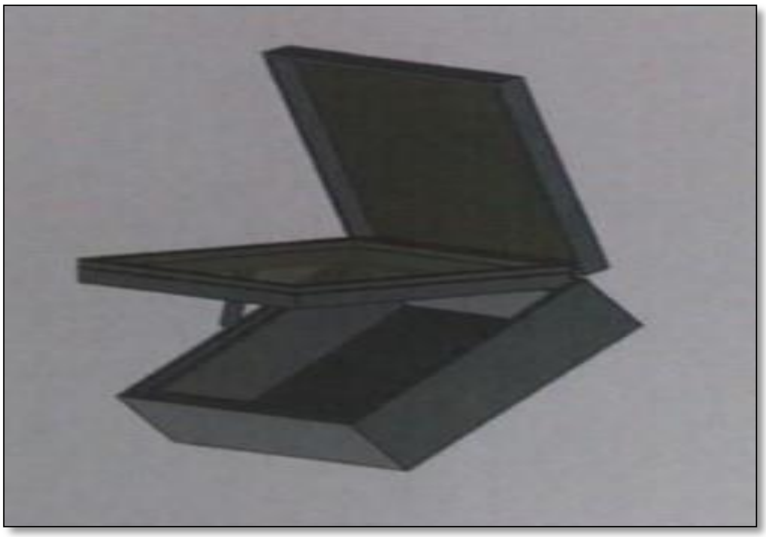

Figure 3. CAD Model of Solar Cooker

It is CAD Model of readily available solar cooker. It is an insulated box consisting of glass and mirror connected in such a way it can be open.

- **Assembly of the System:-**

Figure 4. CAD Model of Solar Water Pasteurizer Assembly

Figure 5. Actual Solar Water Pasteurizer Assembly

III. DETERMINATION OF SOLAR ISOLATION[1]

Date: - 04th April 2018 (94th Day of the Year)
Time: - 12:00 PM (Noon)
Location: - 22°22"N & 70°50"E (Ø)
Location Name: - Campus of Sanjaybhai Rajguru College of Engineering, At Bedi, Rajkot, Gujarat
Tilt: - S-84°
Hour Angle: - ώ = 0°
γ = 0, Since Collector Pointing Due South

- **Declination (δ) on 4th April 2018**
  $\delta = 23.45 \text{ Sin } \{(360/365) * (284+n^{th} \text{ Day of the year})\}$
  $= 23.45 \text{ Sin } \{(360/365) * (284+94)\}$
  $\delta = 5.20°$

- **Sunrise Hour Angle**
  $ώ_s = \text{Cos-1 } [-\tan Ø * \tan\delta]$
  $= \text{Cos-1 } [-\tan (22.22°) * \tan (5.20°)]$
  $= \text{Cos-1 } [-0.408 * 0.091]$
  $ώ_s = 87.87°$

- **Daylight Duration**
  $L_m = (2/15) * ώ_s$
  $= (2/15) * 87.87$
  $L_m = 11.716 \text{ Hours}$

- **Considering Horizontal Surface, θ = 0°**

  $Cos\theta_z$ = Sinδ * SinØ + Cosδ * CosØ * Cosώ
  = Sin (5.20°) * Sin (22.22°) + Cos (5.20°) * Cos (22.22°) * Cos (0°)
  = 0.034 + 0.921
  $Cos\theta_z$ = 0.031
  θ_z = 88.20°

- **Incident Angle of Beam Radiation**

  $Cos\theta_t$ = Cos (Ø-S) * Cosδ * Cosώ + Sin (Ø-S) * Sinδ
  = Cos (22.22°-84°) * Cos (5.2°) * Cos (0°) + Sin (22.22°-84°) * Sin (5.2°)
  = 0.0425-0.0792
  = -0.036
  θ_t = 92.1°

- **Global Radiation On Horizontal Surface**

  H_o = (24/π) I_{sc} (1+0.33 Cos {(360/365)*n} * $^{+w}\int_{-w}$ ($ώ_s$ * SinØ * Sinδ + CosØ * Cosδ * $Cosώ_s$)
  =(24/3.14)I_{sc}(1+0.33Cos{(360/365)*94}*{Cos(22.22°)*Cos(5.20°)*Sin(87.87°) + [(2π*87.87)/360] * Sin (22.22°) * Sin (5.20°)}
  = 7.64(13.53) (0.04) {(092) + (0.05)}
  Ho = 402 W/m^2/Day

- **Determination of Rb**

  R_b = {Cos (Ø-S) * Cosδ * Cosώs + Sin (Ø-S) * Sinδ} / {CosØ * Cosδ * Cosώs + SinØ * Sinδ}
  = {Cos (22.22°-84°) * Cos (5.2°) * Cos (0°) + Sin (22.22°-84°) * Sin (5.2°)} / {Sin (5.20°) * Sin (22.22°) + Cos (5.20°) * Cos (22.22°) * Cos (0°)}
  = 0.397 / 1.383
  R_b = 0.287

- H_{av} = 402 W/m^2/Day
- H / H_{av} = 0.09
  = 0.09 * 402 * R_b
  = 0.09 * 402 *0.287
  H = 10.38 W/m^2

Note: - The effectiveness of the system vary as per the Geological Location and Time. We tested our system at following location and time.
Note: - I_{sc} = International Solar Isolation = 1353 W/m^2/Day (As per the Data of NASA)

REFERENCES

[1] G. D. Rai, "Solar Energy Utilization"