Design and Development of a Solar Parabolic Trough Concentrator with Magnifying Glass

The objective of this research is to design a solar parabolic concentrator with Magnifying glass for water heating and cooking purpose. There were numbers of magnifying glass strips inserted on the reflector in order to achieve maximum reflectivity and to reduce heat losses due to re-radiation. The Instantaneous efficiency was achieved as 25%. The manual tracking system was used to rotate the concentrator as per the maximum availability of solar radiation. The maximum focal length and rim angle were taken as 0.3125m and 450 respectively.

Ending poverty and ensuring sustainability are the defining challenges in recent time. Energy has the answer to both. Access to modern energy services such as electricity, natural gas, modern cooking fuel, etc. are necessary for improved health and agricultural productivity (UNDP, 2001). In order to provide modern energy services to all, clean energy has the answer to both

Clean energy is defined as that energy source or form which when used does not produce negative externalities. Energy derived from sun, wind, water and waves are termed as clean energy sources as they generate very less amount of green house gas.

Nomenclature

w = width of the concentrator

d_r = *diameter* of receiver

CR_G = Geometrical concentrating ratio

CR_0 = Optical concentrating ratio

θ_c = Acceptance half angle of the receiver

θ_R = Rim angle of concentrator

f = Focus point

S = Absorbed solar radiation

$(\tau\alpha)_b$ = Transmittance absorptance product for the beam radiation

Q_u = Useful heat gain

η_{coll} = Efficiency of collector

2. Design and Mathematical Modelling

Here we have calculated the rim angle, focus point, efficiency of collector by considering the preset value of concentrating ratio. By taking the length of concentrator as 2 m, width of collector = 500 mm, the focal length was calculated as 0.3125 m. The rim angle was taken as 45^0.

$$CR_G = w - d_R / \pi d_R$$

$$CR_O = \frac{\sin \phi_R}{\pi \sin \theta_c}$$

$$f = \frac{w^2}{16d} = \frac{0.5 \times 0.5}{16 \times 0.05} = 0.3125\ m$$

$$\cos \phi_R = 2f / \sqrt{0.5w^2 + (d - f)}^2 - 1$$

$$S = I_b R_b (\tau\alpha)_b (\rho\gamma + \frac{d_r}{w - d_r})$$

$$(\tau\alpha)_b = \frac{\tau\alpha}{1 - (1 - \alpha)\rho_d}$$

$$Q_u = F_R A_a \left[S - A_r U_L / A_a (t_f - t_a) \right]$$

$\eta_{coll} = \frac{Q_u}{A_a \times H_b R_b} = \frac{M \times C \times (T2 - T1)}{A \times I}$ where M= mass water taken=2 Litres= 4.2 4.2J/kg^{0}C, I= solar intensity=1000W/m^2 A=area of collector = 2 m^2

By taking above data the Instantaneous efficiency was calculated as 25%.

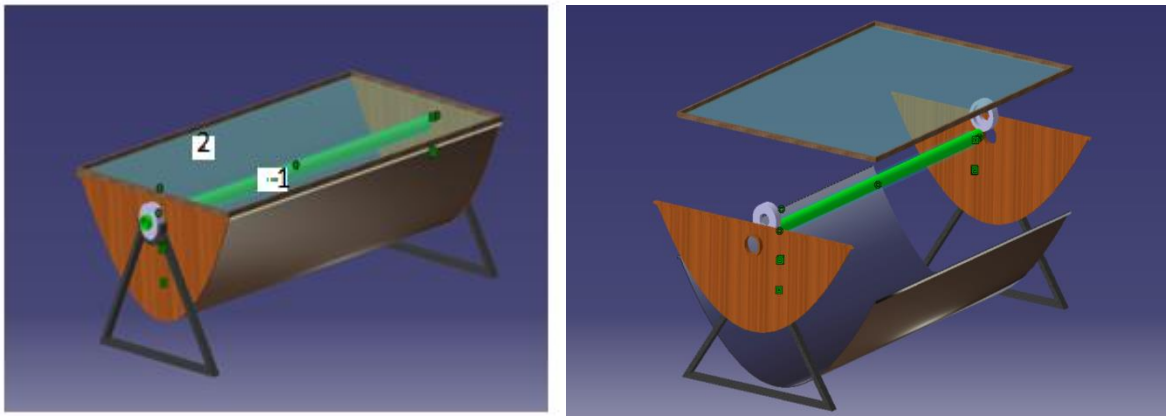

Figure 1 and 2 shows the modelling of solar parabolic concentrator by catia design. 1. Reflector, 2. Receiver tube.

3. Material and methodology

The main component of parabolic concentrator is Receiver and reflector with magnifying glass. The entire body of collector is made up of Aluminium material (3 mm, glazing type).The receiver is tube like structure having internal tube made up of copper (diameter=0.05m),and outer tube made up of glass (diameter=0.08 m).There were numbers of magnifying glass strips inserted on the reflector in order to increase the reflectance. The reflector will focus the incident sun radiation into receiver. The inlet of receiver tube was connected with DC motor which is operated by solar Panel in order to receive continuous

circulation of hot water inside the receiver tube. There was a manual tracking system used to rotate the concentrator as per sun's direction.

3.1 Specification (Table 1 shows the budget estimation of Parabolic concentrator)

Sl. No	**Name of Elements**	**Material**	**Size**
1	Reflecting Sheet, magnifying glass	Aluminium (3mm)	2 m X 1 m
2	Structure	MS	
3	Receiver	Copper Tube and Glass Tube	0.05 m, 0.08 m
4	Pipes	CPVC	Aprox 2 m
5	Storage Tank	Any Material	
6	DC Electric Motor		70 W
7	Solar Panel		70 W
8	Miscellaneous (Gear,Nut,Bolts, Nails, Paper Work etc)		
9	Solar Meter		

4. Conclusion

The PTC can be used for producing steam and cooking purpose which can eliminate the conventional method of cooking. By using magnifying glasses the reflectivity was increased. Further the above work can be extended by taking Chrome vinyl as reflecting surface.