Performance Efficiency Improvement of Parabolic Solar Concentrating Collector (An Experimental Evaluation and Analysis)

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ABSTRACT:
Energy conserved is energy generated'. Energy crisis is one of the crucial problems faced by all countries due to the rapid depletion of natural resources. A viable and an immediate solution at this juncture is the use of renewable energy sources like solar energy, wind energy, etc. A focusing type solar energy concentrator was fabricated and tested to evaluate its performance and to improve its operation efficiency. The experimental evaluations were carried out during the solar window (between 9:00 am to 3:00 pm) using the statistical solar irradiation data and the real time measurements carried out using a pyranometer. Efficiency improvement was tried through different reflecting surfaces, greenhouse effect and selective coating. The energy conservation, preservation of fossil fuel and carbon foot print were estimated along with the cost economics and presented in this article in a very simplified style.

KEYWORDS: Irradiation, Temperature gradient, Conservation, Reflectivity, Greenhouse effect, Selective coating

1. INTRODUCTION

Focusing collector is a device to collect highly intensive solar energy on an energy absorbing surface. Such collectors use optical systems in the form of reflectors or refractors. A focusing collector is a special form of flat plate collector modified by introducing a reflecting (or refracting) surface (concentrator) between the solar radiations and the absorber. Focusing collector can have radiation increase from low value of 1.5 to 2, high values of the order of 10000.

1.1.The advantages of Concentrator Systems

- Reflecting surface requires less material and is structurally simpler than flat-plate collectors. For a concentrator system the cost per unit area of solar collecting surface is therefore potentially less than that for the flat plate collectors.
- The absorber area of a concentrator system is smaller than that of a flat plate system of the same solar energy collection and the insolation intensity is therefore greater.
- Because of the area from which heat is lost into the surroundings, the solar energy collecting area per unit is less than that for a flat-plate collector and because the insolation on the absorber is more concentrated, the working fluid can attain higher temperatures in a concentrating system than in a flat-plate collector of the same solar energy collecting surface.
- Owing to the small area of absorber per unit of solar energy collecting area, selective surface treatment and/or vacuum insulation to reduce heat losses and improve collector efficiency are economically feasible.
- Focusing or concentrating systems can be used for electric power generation when not used for heating or cooling. The total useful operating time per year can therefore be large for a concentrator system than for a flat-plate collector and the initial installation cost of the system can be regained by saving energy in a shorter period of time.
- Because the attainable temperature by concentrating system is higher, the amount of heat which can be stored per unit volume is larger and consequently the heat storage costs are lesser for concentrator systems than for flat-plate collectors.

In solar heating and cooling applications, the higher temperature of the working fluid attainable by a concentrating system makes it possible to attain higher efficiency, in the cooling cycle and lower cost of air conditioning.

1.2. Classification of Concentrating Collectors

❖ Concentrating Collectors may be of the reflecting type utilizing mirrors or of the refracting type utilizing

Fresnel lenses. The reflecting surfaces may be of parabolic, spherical or flat configuration. They must be continuous or segmental.

- As per the optics, the solar concentrators generally can be classified as either point focus or line focus systems. Point focus systems have a circular symmetry and are generally used when high brightness concentration factors are required, as in solar furnaces and central receiver power systems. Line focus systems have cylindrical symmetry and are generally used when medium concentration is sufficient to reach the desired operating temperatures.
- A broad classification of solar concentrators is based on the view fields of the concentrator. If the view field is much larger than the angular size of the sun which is about $1/2^{o}$ (32'), then it is not necessary to continuously orient the concentrator towards the sun as it moves in the sky. Such concentrators are referred to as non-tracking concentrators, in contrast to tracking concentrators which need to track the sun continuously. The achievable concentration ratio by non-tracking concentrators is generally less than that for tracking concentrators.

1.3. Some possible Concentrating Systems

- Plane reflector and plane receiver type: As it can be inferred both reflector and receiver is plane. Such a system is very simple in construction and has the advantage of absorbing some diffuse components of radiation which falls directly on the receiver. However the concentration ratios of this type are relatively low, with a maximum value of four or less than four, ($CR \leq 4$).
- Conical reflector and cylindrical receiver type: The reflector is conical in this type of system and the receiver is cylindrical. Concentration ratio is little higher than that of the first case, it may be of 10 order.
- Fresnel reflector: This type consists of a parabolic shape reflector made up of small segments. Its main advantage is easy fabrication but this type does incur some additional losses of radiation near the rim of each segment. The advantage of linear Fresnel lenses is that the convenient mass production technique of extrusion of thermoplastic materials can be applied to their fabrication. A concentration ratio of about 10 is obtainable using them.
- Parabolic system: In a system consisting of a paraboloidor a parabolic mirror and having receiver at its focal point. The concentration ratios are very high in this system and therefore can be used where high temperatures are required. In cylindrical system, the concentration ratio is lower than the paraboloid counterparts. In both cases the receiver is placed at the focus, i.e. along the focal line in cylindrical parabolic system and at the focal point in paraboloidal system.

2. ORIENTATION AND SUN TRACKING SYSTEMS

For maximum energy collection, orientation of the concentrator and the receiver relative to the direction of the propagation of beam radiation is needed and 'sun tracking' in some degrees will be required for the focusing systems. A variety of tracking mechanisms have been designed: either the reflector or the absorber may be moved. The motions required to accomplish tracking vary with the design of the optical system and a particular resultant motion can be accomplished by more than one system of component motions.

3. MATERIALS OF CONCENTRATING COLLECTORS AND ONSTRUCTION OF REFLECTORS

For materials choosing, the most critical properties for a concentrating collector are:

- The reflectance of the reflector.
- The transmittance of the glazing.
- Absorptivity (α) and emissivity (ε) of the absorber coating.

No real surfaces are perfectly specular due to micro roughness or surface undulation. The lack of specularity contributes to beam spreading the same way as mirrors do. For collectors with low concentration, the reflector need not be highly specular. Aluminium with a total reflectance of 85 to 90 percent and silver with total reflectance about 95 percent are the best reflective surfaces for solar energy applications, except for special cases where total internal reflection can be employed. Because of spectral variation, a single precise value of reflectance can be obtained only by integrating the spectral reflectance over a particular solar spectrum.

3.1. Protection

First surface mirrors require protection from the environment. Aluminium sheet can be protected very well by anodization, which produces an oxide coating that can survive outdoor exposure and washing. If an aluminium surface is not exposed to the environment, a thin coating of MgF_2 or SiO will suffice. Acrylic and Teflon coatings have also been used. Teflon is impractical because its electrostatic properties cause to attract dust. Acrylic does not suffer from this problem and may be a good coating even for outdoor exposure of aluminium mirrors. Silver is difficult to be protected except as a second surface mirrorbehind glass. An acrylic coating is likely to have pin holes through which pollutants will penetrate and attackthe silver. Micro sheet silvered glass appears to be the mostpromising reflector materialif suitable techniques for handling it will develop. (e.g. lamination to plastic film substrate).

3.2. Etching

Glass is the most durable material; it should have low iron content to avoid excessive absorption losses. Of particular interest is etched glass, a low-cost anti-reflection coating. Reflection losses can be reduced by etching from 4 percent per surface to about 1 percent at normal incidence.

A double etching process can yield even better results, although at higher costs. In mass production, etching of the cover glazing for the receiver will always be cost effective because of the relatively small area and because this glazing is sufficiently well protected from the environment not to degrade by accumulation of dirt. If the glazing is expected to be exposed to temperature, borosilicate glass (Pyrex) is recommended; it is more expensive than soda lime (window) glass. An etching process for borosilicate glass is also available. Acrylic (plexiglass) is suitable as a cover material for the whole collectors, and in particular it is excellent as material for Fresnel lenses. As the cover of the receiver, acrylic is less practical because of its low service temperature limit (about 100^oC); also, ultraviolet damage may be excessive as a result of the concentration of solar radiation near the receiver.

3.3. Choice of α and ε

When interpreting quoted values of α and ε, one should keep in mind the following points:

- α depends on the assumed solar spectrum
- α will in general decrease with the angle of incidence, but usually only normal incidence values are quoted. In concentrating collectors the angle of incidence of some rays at the absorber will deviate strongly from the normal direction (by 30 to 90^o depending on concentrator optics). Black chrome maintains a high absorbency up to 60^o, but multilayer interference films tend to drop off significantly around 45°.
- ε increases with temperature, because of the spectral shift of black body radiation and because of the changes in surface properties.
- A single number such as α/ε does not adequately characterize a selective surface (it only determines the stagnation temperature in vacuum).

3.4. Parts of Reflector

For the discussion purposes, the reflector is divided into two parts:

- Reflective lining:

It is desirable to use a reflective material with a maximum specular reflectance over the period of consistent uses with costs. Also there is possibility of renewing a lining by putting on a new layer of reflective plastic tape.

- Shell and Supporting structure:

It influences the intercept factor and the collector operation is dependent upon the ability of structure to maintain the shape and orientation of the reflector. Since orientation and shape are critical factors, the following points must be kept in mind while designing:

- ➢ Shell and structure must be supported in various positions so that to have minimum distortion due to its weight.
- ➢ Wind effects.

Fig. 1. Parabolic Collector with Aluminium Reflector

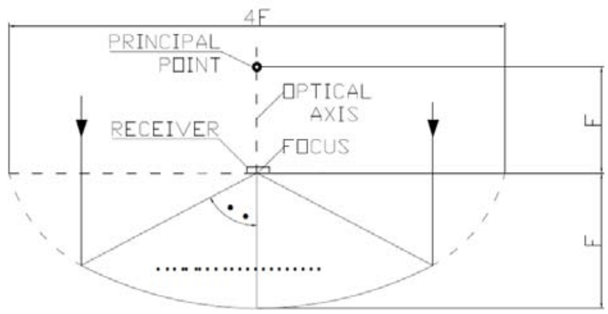

Fig. 2. Basic Paraboloid Geometry

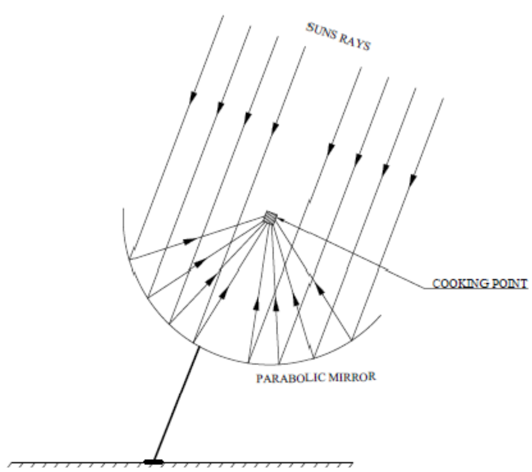

Fig. 3. Focal point for the Receiver Location

The photograph in 1 gives an overall view of the fabricated parabolic concentrator with aluminium segments assembled over the steel structure. The overall diameter of the paraboloid was maintained in multiples of focal length as indicated by the fig 2 in order to optimize the output. The exact location of the cooking pot for the experimental evaluation is shown by the fig 3.

4. EXPERIMENTAL EVALUATION

The working of solar parabolic Collector was examined in different configurations as shown below:

- ✓ Aluminium Receiver with aluminium collector
- ✓ Aluminium Receiver with selective coating
- ✓ Aluminium Receiver employing greenhouse effect
- ✓ Selective coated Aluminium Receiver with greenhouse effect
- ✓ Aluminium Receiver with additional reflective lining over the collector
- ✓ Selective coated Receiver with additional reflector lining over the collector
- ✓ Aluminium Receiver with mirror collector

The readings were taken for five days, they were analyzed separately for each day and the efficiency and losses were calculated using the average temperature rise of the five days.

4.1. Estimation of Efficiency

Collector radius = r = 0.7m

Surface area of collector = $2 \times \pi \times r^2 = 2 \times \pi \times 0.7^2 = 3.07876 m^2$

Receiver radius = r_1 = 0.104m

Receiver height = h = 0.112m

Exposed area of receiver = $2 \times \pi \times r_1^2 + 2 \times \pi \times r_1 \times h$
$= 2 \times \pi \times 0.104^2 + 2 \times \pi \times 0.104 \times 0.112 = 0.14114 m^2$

Table 1. Day 1 – Plain Aluminium Receiver

Time	T(°C)	Temperature gradient ΔT(°C)	Irradiation I(watts/m²)	ΔT/I	E Out (kcal)	E In (kcal)	Efficiency-η
10:30	41	-	820	-	-	0	-
11:00	52	11	869	0.0126	55	1147	4.8
4.85	64	23	898.5	0.02559	115	2371	
4.31	73	32	937.5	0.03413	160	3711	
3.96	81	40	957	0.0417	200	5052	
4.04	**90**	**49**	**918**	**0.0533**	**245**	**6058**	
1:30	99	58	878.5	0.06602	290	6956	4.16
2:00	99	58	790.5	0.07337	290	7303	3.97
2:30	100	59	683.5	0.08632	295	7217	4.09
3:00	100	59	566	0.1042	295	6723	4.38
						Average	4.28

T– Maximum temperature of water, ΔT= Temperature gradient = Maximum temperature-initial temperature for water

Table 1 shows the experimental observations recorded during the experimentation work, on a particular day, carried out using a plain aluminium receiver for heating water

Area of collector = $3.07876 m^2$; Mass of water used for heating = 5kg; Time = 1:00PM

Time duration = 2 ½ hour up to 1.00pm = 5/2 × 3600 = 9000 s

T = 90°C; I = 918watts/m²- real time reading obtained by pyranometer

$$\Delta T = 90 - 41 = 49^{o}C$$

$$\Delta T / I = 49/918 = 0.0533\ ^{o}Cm^2/watts$$

$$E\ Out = \Delta T \times \text{mass of water} = 49 \times 5 = 245\ kcal$$

$$E\ In = \frac{I_{avg} \times \text{Area of Collector} \times \text{Time duration}}{4.187 \times 1000}$$

$$= \frac{918 \times 3.07876 \times 9000}{4.187 \times 1000} = 6058 kcal$$

$$\eta = \text{Efficiency} = \frac{E\ Out}{E\ In} = \frac{245}{6058} = 4.04\%$$

A graphical plot also could be obtained between ΔT/I and η

Table 2. Average Maximum Temperature obtained with Plain Aluminium Receiver During Experimentation on Different Days

Time	Day 1	Day 2	Day 3	Day 4	Day 5	Average
10:30	41	30	29	31	31	32.4
11:0	52	36	41	53	35	43.4

0						
11:30	64	49	51	69	42	55
12:00	73	57	61	80	50	64.2
12:30	81	63	70	96	59	73.8
1:00	90	64	70	99	67	78
1:30	99	69	79	102	75	84.8
2:00	99	78	86	103	90	91.2
2:30	100	84	102	104	92	96.4
3:00	100	83	103	103	95	96.8

Table 2 shows the average values of the maximum temperatures attained during the experiments carried out over several days in the solar window. This maximum average temperature is used for the performance evaluation.

4.2. Estimation of Losses

Water collected in the Receiver = 5kg

Time duration in seconds for raising the temperature $= 4\ \frac{1}{2} \times 3600 = 16200s$

$T_i = 32.4^oC$ $T_f = 96.8^oC$

$T_{av} = (T_i + T_f)/2 = (32.4+96.8)/2 = 64.6^oC$

$\Delta T = T_f - T_i = 96.8 - 32.4 = 64.4^oC$

E Out = ΔT × mass of water = 64.4 × 5 = 322kcal

$$P\ out = \frac{E\ Out \times 4.187 \times 1000}{\text{Time duration in seconds}} = \frac{322 \times 4.187 \times 1000}{16200}$$

$= 83.233W$

$$E\ In = \frac{735 \times \text{Surface area of collector} \times \text{Time duration}}{4.187 \times 1000}$$

$$= \frac{735 \times 3.07876 \times 16200}{4.187 \times 1000}$$

$= 8755.3846$ kcal

Where 735 indicate average irradiation in watts / m^2 measured during experimentation.

$$P\ in = \frac{E\ In \times 4.187 \times 1000}{\text{Time duration in seconds}} = \frac{8755.3846 \times 4.187 \times 1000}{16200}$$

$= 2262.888$ W

$$\text{Efficiency} = \frac{P\ out}{Pin} \times 100 = 3.677\%$$

Radiation loss = $\varepsilon \times \sigma \times$ Surface area of receiver $\times (T_f^4 - T_i^4)$

$= 0.95 \times 5.67 \times 10^{-8} \times 0.141 \times [(273+96.8)^4 - (273+32.4)^4] = 76.312$ W

Convection Loss = $h \times A \times \Delta T$

$$\text{Grashof Number} = Gr = \frac{g \times \beta \times x^3 \times \Delta T}{\nu^2}$$

$g = 9.81 m/s^2$

$$\text{Volume expansion coefficient} = \beta = \frac{1}{T_{av}+273} = 2.9620 \times 10^{-3} /^oK$$

$x = h = 0.112m$

$\nu = 20.3254 \times 10^{-6}\ m^2/s$

$k = 0.02928$ W/mK

$Pr = 0.6951$

$$Gr = \frac{9.81 \times 2.9620 \times 10^{-3} \times 0.112^3 \times 64.4}{(20.3254 \times 10^{-6})^2}$$

$= 6.3637 \times 10^6$

$GrPr = 6.3637 \times 10^6 \times 0.6951 = 4.4234 \times 10^6$

$Nu = 0.59 \times (GrPr)^{0.25}$

$= 27.0578$

$$h = \frac{Nu \times k}{L} = \frac{27.0578 \times 0.02928}{0.112}$$

$= 7.0736$

$Q_{side} = h \times A \times \Delta T = 7.0736 \times 2 \times \pi \times 0.104 \times 0.112 \times 64.4$

$= 33.339$ W

For Top:

$$\text{Characteristic Diameter} = L = \frac{A}{Pr2} = \frac{\pi \times r^2}{\times \pi \times r} = \frac{\pi \times 0.104^2}{2 \times \pi \times 0.104}$$

$= 0.052m$

$$Gr = \frac{g \times \beta \times L^3 \times \Delta T}{\nu^2} = \frac{9.81 \times 2.9620 \times 10^{-3} \times 0.052^3 \times 64.4}{(20.3254 \times 10^{-6})^2}$$

$= 6.3690 \times 10^5$

$GrPr = 6.3690 \times 10^5 \times 0.6951 = 4.4270 \times 10^5$

$Nu_{top} = 0.27 \times (GrPr)^{0.25} = 0.27 \times (4.4270 \times 10^5)^{0.25}$

$= 6.9645$

$$h_{top} = \frac{Nu_{top} \times k}{L} = \frac{6.9645 \times 0.02928}{0.052} = 3.9215$$

$Q_{top} = h \times A \times \Delta T = 3.9215 \times \pi \times 0.104^2 \times 64.4$

$= 8.5813$ W

For bottom:

$$\text{Characteristic Diameter} = L = \frac{A}{Pr2} = \frac{\pi \times r^2}{\times \pi \times r} = \frac{\pi \times 0.104^2}{2 \times \pi \times 0.104}$$

$$Gr = \frac{g \times \beta \times L^3 \times \Delta T}{\nu^2} = \frac{9.81 \times 2.9620 \times 10^{-3} \times 0.052^3 \times 64.4}{(20.3254 \times 10^{-6})^2}$$

$= 0.052m$

$GrPr = 6.3690 \times 10^5 \times 0.6951 = 4.4270 \times 10^5$

$Nu_{bottom} = 0.54 \times (GrPr)^{0.25} = 0.54 \times (4.4270 \times 10^5)^{0.25}$

$= 13.9290$

$$h_{bottom} = \frac{Nu_{bottom} \times k}{L} = \frac{13.9290 \times 0.02928}{0.052} = 7.843$$

$Q_{bottom} = h \times A \times \Delta T = 7.843 \times \pi \times 0.104^2 \times 64.4$

$= 17.162$ W

$Q_{tot} = Q_{side} + Q_{top} + Q_{bottom} = 33.339 + 8.5813 + 17.162$

$= 59.0823$ W

Unaccounted Loss = P In – Radiation Loss – Convection loss – P Out

$= 2262.888 - 76.312 - 59.0823 - 83.223 = 2044.2707$ W

$$\text{Percentage radiation loss} = \frac{\text{Radiation loss}}{P\ In} \times 100$$

$$= \frac{76.312}{2262.888} \times 100$$

$= 3.3723\%$

$$\text{Percentage convection loss} = \frac{\text{Convection Loss}}{P\ In} \times 100$$

$$= \frac{59.0823}{2262.88} \times 100$$

$$= 2.610\%$$

$$\text{Percentage unaccounted loss} = \frac{\text{Unaccounted Loss}}{\text{P In}} \times 100$$

$$= \frac{2044.2707}{2262.88} \times 100$$

$$= 90.3389\%$$

4.2.1. Utilization chart –Plain Aluminium Receiver

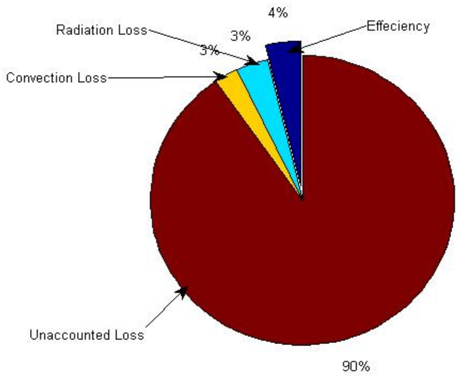

Fig. 4. Loss estimation

The experiment was carried out for different set ups and different configurations for different days. It was observed that introducing a glass enclosure and giving a selective coating over the receiver gave a better output. It was also found that the required temperature could be obtained in a short span of time compared to other set ups and configurations, at the same irradiation levels. Employing the greenhouse effect and using selective coating simultaneously have resulted in required output in a reduced time duration and a better performance of the parabolic collectors. The utilization chart shown in 7 obviously indicates the improvements compared to the chart shown in 4. Just for the sake of convenience photographs, utilization charts and the calculations for other configurations were not shown in this article.

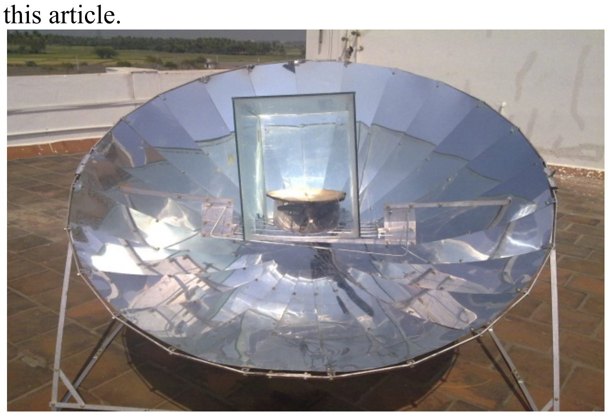

Fig. 5. Parabolic Collector Using Glass Enclosure over the Receiver and Employing Green House Effect

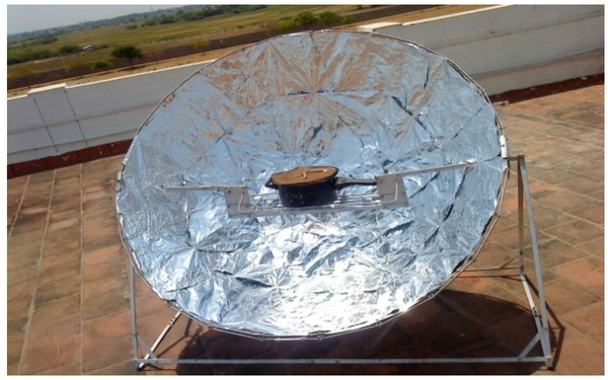

Fig. 6. Parabolic Collector Using Selective Coating on the Receiver

The experimental set up for the plane aluminium receiver employing greenhouse effect is shown in the photograph 5.This set up was not found to give a better performance. However the experimental set up shown in the photograph 6 , namely the experimentation with black coated receiver had given relatively a better performance.The results are presented in the table 3.

Table 3. Average Maximum Temperature Obtained Using Green House Effect and Selective Coating over the Receiver

Time	Day 1	Day 2	Average
10:30	34	33	33.5
11:00	91	76	83.5
11:30	100	96	98
12:00	101	100	100.5

P out = 259.749 W
P in = 2945.3 W
Radiation Loss = 85.1172 W
Convection Loss = 62.1406W
Unaccounted Loss=2538.3W
Efficiency =8.8190%
Percentage Radiation Loss = 2.8899%
Percentage Convection Loss = 2.1098%
Unaccounted loss = 86%

Various configurations and test setups were evaluated and it was found that application of selective coating on the receiver and the introduction of a glass enclosure over the receiver simultaneously, have improved the performance and better results were obtained compared to the other configurations and test set ups.For the sake of convenience and simplicity, only the better results are brought out in this article.

4.2.4. Utilization chart for the configuration with selective coating on Receiver and a Glass enclosure over the Receiver

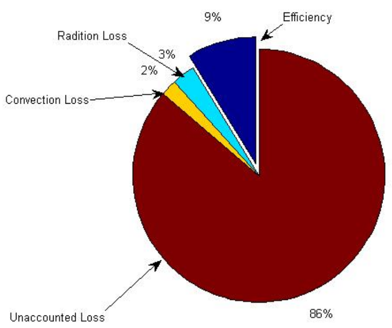

Fig.7. Loss estimation after utilization

The introduction of glass enclosure has resulted in greenhouse effect and the selective coating has caused the behavior of black body for the receiver. This arrangement has reduced the time duration to get the required maximum temperature.

5. ENERGY CONSERVATION

The required heat energy to increase the temperature of five liters of water from an average initial temperature of 28°C to 100°C = 5x4.187x (100-28) = 1507kJ= 1507/4.187
= 360kcal = 360/860 = 0.42kWh
Considering an efficiency of 85% for electric heating, the electricity consumption = 0.42/0.85 = 0.5 units
Considering a small family of four members, the consumption of electricity/day for heating 20 liters of water
= 4x0.5units= 2 units
Consumption per annum 2x360= 720 units
Using a parabolic solar concentrator and considering 300 days of sunshine in a year, the saved energy =
(300) /(360) x 720 = 600 units
Financial savings = 600xRs.4.00 /unit = Rs.2400.
Savings will be more if cooking is also taken into consideration.

6. PAYBACK PERIOD

Cost of fabricated Parabolic collector= Rs.13000/
Annual saving = Rs.2400/-
Payback period = 13000/2400 = 5.4 years.
This figure will come down if cooking is also considered using parabolic concentrator.

7. LPG CONSERVATION

Required heat energy for heating 20 liters of water per family for drinking purpose = 0.42x4kWh = 1.68kWh
Considering 60% efficiency for gas heating, the required heat energy = (0.42 x4)/0.60 = 2.8kWh = 2.8x860= 2408kcal
= 2408x4.187= 10,082kJ
The calorific value of LPG = 42000kJ/kg
Amount of LPG required per year 10082 x 360/42000 =86kg
Weight of domestic LPG cylinder = 14.2kg
Number of cylinders required per annum for providing hot water for one small family at the rate of 20liters /day
= 86/14.2 = 6 cylinders
If Parabolic solar heater is used, number of cylinders saved per year (300)/(360) x 6 = 5 cylinders
Financial savings = 5 x Rs.400/cylinder = Rs.2000/-

8. CARBON FOOTPRINT

The greenhouse gas carbon-di-oxide liberated per unit consumption of electricity generated from fossil fuel
= 1kg approximately
Amount of CO2reduction per annum per family for hot water production = 600kg. This figure will go up if cooking
isalso considered using parabolic concentrator.

9. SOLAR IRRADIATION

Table 4. NASA Solar Monthly averaged Irradiation

Month	Solar Irradiation
January	4.74 kWh/m^2/day
February	5.74 kWh/m^2/day
March	6.47 kWh/m^2/day
April	5.94 kWh/m^2/day
May	5.81 kWh/m^2/day
June	5.29 kWh/m^2/day
July	5.01 kWh/m^2/day
August	5.17 kWh/m^2/day.
September	5.39 kWh/m^2/day
October	4.58 kWh/m^2/day
November	4.09 kWh/m^2/day
December	4.22 kWh/m^2/day

Statistical Data – Solar Irradiation for the months under consideration from NASA for Latitude 10/ Longitude 78 were also furnished for reference in the table 9.1.This data could be used for the performance evaluation if the field measurements for the insolation were not possible using a pyranometer shown in fig.8.

10. FUTURE SCOPE

It is possible to improve the efficiency of the parabolic collector by using high reflective materials and special coating properties. Some of the materials are furnished below:

Table 5. Collector Cover Materials Properties

Material Name	Index of refraction (n)	Transmissivity τ(for λ = 0.2-4μm)	Temperature limits °C
Lexan (polycarbonate)	1.586	72.6	125-135 (service temperature)
Teflon FEP (Fluoro carbon	1.343	89.8	200 (continuous use)
Sunadex white crystal glass(0.01%,iron oxide glass)	1.50	91.5	200 for continuous operation
Float Glass	1.518	78.6	650

Table 6. Special Coating Properties

Type of Coating	α	ε 100° C	Temperature °C Air/Vacuum	Life(year) Air/Vacuum
Interference	0.94	0.10	175/200	5/30
Black Chrome	0.96	0.12	175/200	15/30
PbO_2	0.98	0.3	100/150	20
Anodic Aluminium	0.95	0.80	250	50

The alternate materials for the collector base and their properties in the tables 5 and 6 are for the study and exploration in the future for betterment.

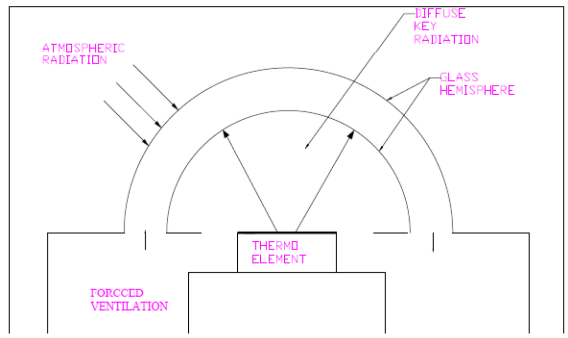

Fig. 8. Pyranometer Schematic for the Measurement of Solar Irradiation

Table 7. Solar Irradiation Measurement with Pyranometer

Time	Irradiation (mv)	Irradiation (w/m^2)
08.30	2.5	488
09.00	3.1	605
09.30	3.8	742
10.00	4	781
10.30	4.2	820
11.00	4.6	898
11.30	4.7	918
12.00	4.7	918
12.30	4.9	957
1.00	4.7	918
1.30	4.4	859
2.00	4.2	820
2.30	3.8	742
3.00	3.1	605
3.30	2.6	507
4.00	2.2	430

$$\text{Pyranometer Factor} = 5.12\times10^{-6}$$

$$\text{Radiation (W/m}^2) = \frac{\text{Radiation (mV)}}{\text{Pyranometer Factor}}$$

The solar irradiation levels were measured in the experimental site using a Pyranometer and the results are shown in table 7.

11. CONCLUSION

Utilization of renewable energy provides greener environment by reducing the release of carbon dioxide and other harmful pollutants to atmosphere. It also ensures preservation of fossil fuels and conservation of electrical energy. In this paper the main highlight is to indicate the vast scope in improving the performance of Parabolic Solar Concentrator through appropriate selective coating and by using an additional layer of high reflective material in the collector. This not only improves the performance but also reduces heating time. Popularizing these collectors in all sectors with mentioned developments will provide an environment for a sustainable growth.

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