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CYLINDRICAL PARABOLIC SOLAR CONCENTRATOR

Muhammad Anwar Chaudhri & Zafar Ahmad Hasni
Department of Physics, University of Agriculture, Faisalabad

A cylindrical parabolic solar concentrator has been designed using mirror strips of high reflecting coefficient. The simplicity of the design ensures its easy manufacturing even in remote villages with very little workshop facilities. Its thermal performance is comparable with other designs requiring special manufacturing skills.

INTRODUCTION

The energy crisis in the world, once again, seems to be at its peak because of conflict in the Gulf area; it has become imperative that search for other renewable energy resources be seriously undertaken. Under the prevailing circumstances solar energy seems to be the only such resource, being available in abundance at almost all places, especially in Pakistan that may help tide over the crisis.

The Department of Physics, University of Agriculture, Faisalabad has been making efforts since 1980 for developing cheap and efficient devices, within the reach of local know–how, for harnessing this freely available source of energy, which is pollution free and as such is most appreciable. Like many other national and international organizations, the department has developed and tested various solar devices, such as solar collectors, different types of reflectors and concentrators for capturing solar energy.

The research work reported in this paper aimed at fabrication and studying the performance of a cylindrical parabolic solar reflector. The importance of this work lied in making the device a unit involving simple design and easy fabrication through ordinary know–how available with the local rural manpower.

MATERIALS AND METHODS

The cylindrical parabolic solar reflector under study was fabricated using indigenous material (mirror strips and metal fittings). It consisted of the following major parts:

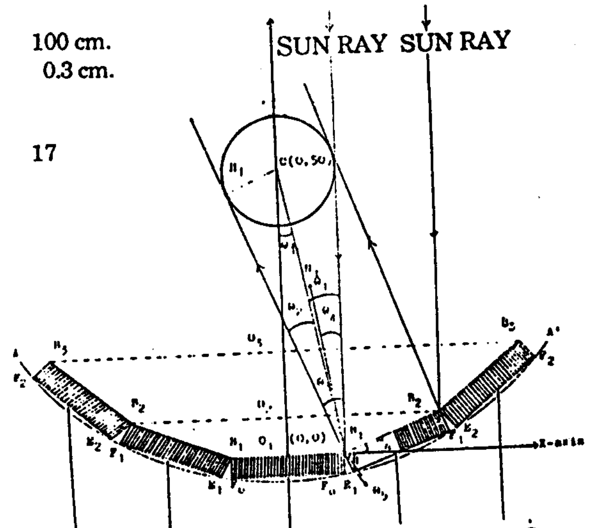
1. Primary reflector ------- a cylindrical parabolic surface made by arranging mirror strips along the cylindrical concave metal frame having 50 cm focal length and 1.0 m^2 aperture area (Figure 1).
2. Secondary reflector ------- a stainless steel device to block the radiation flux flowing to pass the fluid–carrying–tube without trapping (Figure 2).
3. Collector assembly ------- designed by using two co–axial aluminium pipes enclosed in two co–axial colourless, transparent, circular glass tubes (Figure 2). The two co–axial aluminium pipes have been used in order to increase the water surface area in contact with the hot heat exchanging surface. The air

trapped in between the two outer glass tubes acts as an insulator and minimizes the heat dissipation from the hot water.

4. Reflector mountings ------ a frame work helping the azimuthal type of adjustments by the rotation of a vertical central axle and tilting of the reflectors around a horizontal axis.

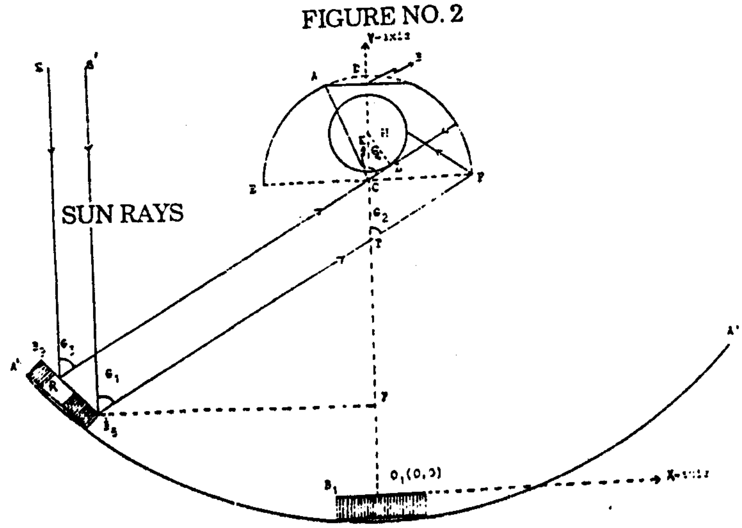
FIGURE NO. 1

Length of each strip = 100 cm.
Thickness of each strip = 0.3 cm.
Width varied from 6.00 to 6.65 cm.
Total No. of Strips = 17



FOR PRIMARY REFLECTOR

FIGURE NO. 2



FOR SECONDARY REFLECTOR

Table 1. Average values of various parameters with constant water flow rate as 5 litres/hour

Time	Orientation	Tilt angle	Intensity	Temperatures				Rate of heat collection per unit area of collector
				Ambient	Inlet	Outlet	Difference	
t	ø	O	I	T	T_c^1	T_c^2	$(T_{c2} - T_{c1})$	(P_{sol})
Hr	Deg.	Deg.	Lux	C°	C°	C°	C°	Kcal/hr
1130	24.3	43.2	321	28.3	30.1	51.0	20.9	104.5
1140	22.3	42.8	337	29.0	30.7	52.3	21.6	108.0
1150	20.3	42.5	349	29.5	31.0	53.4	22.4	112.0
1200	18.5	42.4	352	29.6	31.2	53.8	22.6	113.0
1210	15.8	42.4	362	30.4	30.9	54.3	23.4	117.0
1220	13.3	42.8	370	31.1	30.2	54.2	24.0	120.0
1230	10.5	43.4	373	31.4	29.5	53.9	24.4	122.0
1240	7.7	43.9	372	31.2	28.6	52.8	24.2	121.0
1250	4.4	44.6	367	30.6	28.2	51.7	23.5	117.5
1300	1.8	45.5	361	30.0	28.2	51.1	22.9	114.5

The complete assembly was placed in the open sun, being supplied with cold water through the water flow controlling unit by means of flexible plastic pipes. Flow of water was adjusted to maintain an appropriate temperature gradient. Temperatures at the inlet and outlet points of the collector assembly were recorded at regular intervals.

Thermal performance of the unit was accounted for by an equation advocated by Brown and Howell (1976):

$$Q_{sol} = M_c C_p (T_c^2 - T_c^1)$$

where, Q_{sol} = Rate of collection of heat energy (i.e. useful solar energy),

M_c = Flow rate of the fluid,

C_p = Specific heat of the fluid,

T_c^1 = Collector inlet (fluid) temperature, and

T_c^2 = Collector outlet (fluid) temperature.

RESULTS AND DISCUSSION

Data regarding average of water inlet and outlet temperatures and quantity of heat absorbed by water (flowing at the rate of five litres per hour) have been given in Table 1.

Thermal performance of the unit was found as giving maximum average rate of heat absorbed as 122.0 Kcal/hr/m^2 during the month of November while the rate of daily maximum heat collected was 117.5, 117.5, 115.0, 125.0 and 135.0 Kcal/hr/m^2. These figures were comparable with the results of Parabolic Step Reflector type Solar Cookers fabricated and tested by Garge *et al.* (1976), reportedly bringing 1.0 litre of water to boiling point within 30 minutes; estimated heat energy absorption as being 140 Kcal/hr/m^2. Moreover, these results were also comparable (with added merit of simplicity of design) with the result achieved by Shaukat (1985), who reported that the absorbed heat energy was 158 Kcal/hr/m^2 by testing his Parabolic Step Reflector at the University of Agriculture, Faisalabad. With the above reported results it seems that this design can be used as water heater or can supply heat to devices working on low temperatures such as solar refrigerators.

REFERENCES

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