PERFORMANCE ANALYSIS OF PARABOLIC SOLAR DISH COLLECTOR FOR STAINLESS STEEL AS REFLECTING MATERIALS

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ABSTRACT

In this research work the performance analysis of parabolic solar dish collector is done with the use of stainless steel as reflecting materials. The Parabolic Dish Solar Collector system is made for hot water production. Water is recirculating from the storage tank to the absorber tank with the help of a pump. This analysis is carried out to study variation in temperature of water in the storage tank to a maximum value. An analysis is mainly based on the reflector material. The values of useful heat gain, instantaneous efficiency, hourly thermal efficiency and overall thermal efficiency, are calculated and their variation with solar intensity and time are plotted graphically. Solar intensity is measured by solar power meter.

INTRODUCTION

A solar thermal collector functions by gathering solar energy in the form of heat. It is a crucial part of solar heating systems. In comparison to flat plate collectors, parabolic solar dish collectors can capture more energy per unit surface area.

Because of how effectively they work in cold and dim light settings and how little they cost compared to other technologies, we utilize them almost exclusively. Between 1100C and 1600C are the operating temperatures for these collectors. This price range is suitable for heating domestic water as well as a number of space heating systems, such as radiant flooring and hydraulic air-handling devices.

EXPERIMENTAL SETUP

Fig. Photograph of the experimental setup

The experimental set up is shown in Fig. 1. A solar parabolic dish, an absorber, and water which is pumped through the system from a water tank make up this experimental configuration. The water is flowed from the storage tank to the absorber via flexible lines. The parabolic solar dish's focal point is where the absorber is situated.

The solar rays strike the reflective surface, are reflected, and then focus on the absorber's surface. The stainless steel sheet used to make the parabolic dish that is extremely reflective. The reflector sheet has been divided into manageable sections and fastened to a parabolic shape. It is possible to manually track the sun.

MEASURING DEVICES AND INSTRUMENTS

Thermocouples are used to measure the temperatures at various locations. The thermocouples are connected to a digital temperature indicator, which provides the temperature with a resolution of 0.10C. Throughout the day, a solar power meter is used to measure the amount of solar radiation present.

OBSERVATIONS

Table1. Observation Table for Stainless steel (Time-10 am to 11 am)

Sr. no	Time	Temperatures in ^{0}C							Solar intensity (W/m^2)
		T_1	T_2	T_3	T_4	T_5	T_6	T_7	
1	10:10	26.4	25	25.2	37.8	35.5	37.2	25.2	656
2	10:20	27.5	26.1	25.7	39.1	37.3	40.3	25.4	627
3	10:30	27.5	25.9	26:0	37	35.6	37.4	26.0	823
4	10:40	28.0	26.3	26:4	37.4	35.9	38.1	26.4	822
5	10:50	28.2	26.9	26:9	37.5	35.4	40.3	26.5	658
6	11	28.7	27.3	27.3	37.5	37.7	40.2	27.2	778

Table 2. Observation Table for Stainless steel (Time-11 am to 12 pm)

Sr. no	Time	Temperatures^{0}C							Solar intensity (W/m^2)
		T_1	T_2	T_3	T_4	T_5	T_6	T_7	
1	11:10	25.2	24.5	24.5	38.1	36.5	41.6	23.8	630
2	11:20	25.9	24.6	24.6	36.4	34.3	38.2	26.4	996
3	11:30	26.3	24.9	25	33.5	33.9	35.8	25	924
4	11:40	27.5	25.7	25.8	37.3	35.9	38.9	25.8	983
5	11:50	27.9	26.3	26.3	34.9	33.8	38.2	26.3	1047
6	12	27.9	26.6	26.6	36.5	35.2	40	26.8	1096

Table 3. Observation Table for Stainless steel (Time-12pm to 1pm)

Sr. no	Time	Temperatures ^{0}C							Solar intensity (W/m^2)
		T_1	T_2	T_3	T_4	T_5	T_6	T_7	
1	12:10	22.5	20.5	20.5	34.9	34	37.6	19.7	1036
2	12:20	24.6	21.8	21.8	36.2	35.4	43.1	21.6	1108
3	12:30	24.2	22.5	22.7	31.8	31.8	35.7	22.5	981
4	12:40	25.8	24.3	24.5	34.5	34.2	32.3	24.3	1100
5	12:50	26.5	25.1	25.2	37.4	34.9	41	24.9	1018
6	01	26.8	25.8	25.8	33.7	32.7	37.7	25.9	874

Table 4. Observation Table for Stainless steel (Time-1 pm to 2pm)

Sr. no	Time	Temperatures ^{0}C							Solar intensity (W/m^2)
		T_1	T_2	T_3	T_4	T_5	T_6	T_7	
1	01:10	23.4	20.8	20.8	33	35.2	38.1	19.1	1018
2	01:20	24.4	21.8	21.8	31.8	35.6	40.1	21.4	1066
3	01:30	25.4	23.5	23.4	35.7	34.2	39.7	22.9	1058

4	01:40	26.5	25.0	25.0	28.8	30.5	32.9	24.6	952
5	01:50	27.5	26.7	26.6	34.4	32.8	35.6	25.9	991
6	02	28.6	27.9	28.0	33.5	32.5	36.3	27.5	800

Table 5. Observation Table for Stainless steel (Time-2pm to 3pm)

Sr. no	Time	Temperatures ^{0}C							Solar intensity (W/m^2)
		T_1	T_2	T_3	T_4	T_5	T_6	T_7	
1	02:10	21.4	21	21.1	30.5	34.1	33.6	19	834
2	02:20	23.1	21.9	21.9	34.7	35.6	38.5	21.3	1080
3	02:30	25.2	24.4	24.5	25.5	32.6	34.5	23.8	844
4	02:40	27.5	26.6	26.7	26.7	37.8	41.6	26.2	909
5	02:50	28.2	27.9	28.0	28	34.0	37.0	27.4	684
6	03	29.5	29.3	29.4	29.4	33.7	38	28.8	806

Table 6. Observation Table for Stainless steel (Time-3pm to 4 pm)

Sr. no	Time	Temperatures ^{0}C							Solar intensity (W/m^2)
		T_1	T_2	T_3	T_4	T_5	T_6	T_7	
1	03:10	21.8	22.2	22.4	33.3	34.2	36.6	19.5	439
2	03:20	24.3	23.6	23.6	35.3	35	36.9	23.1	523
3	03:30	27.7	27.4	27.5	32.6	32.7	35.1	26.5	724
4	03:40	30.0	29.7	29.9	35.5	34.5	35.5	29.2	662
5	03:50	31.5	31.7	31.9	31.4	30.6	32.4	31.2	785
6	04	33.2	33.3	33.5	34.0	34.1	36.4	32.8	942

Table 7. Observation Table for Stainless steel (Time-4pm to 5pm)

Sr. no	Time	Temperatures ^{0}C							Solar intensity (W/m^2)
		T_1	T_2	T_3	T_4	T_5	T_6	T_7	
1	04:10	24.3	23.8	25.8	31.7	31.3	32.1	22.7	480
2	04:20	27	26.4	26.4	33.6	34.6	31.8	25.8	750
3	04:30	28.4	28.3	28.4	32.4	35.5	32.3	27.8	880
4	04:40	29.2	29.2	29.4	32.1	32.1	31.1	28.9	754
5	04:50	30.7	30.7	30.9	33.1	32.6	33.5	30.3	542
6	05	32.7	32.7	31.8	35.1	34.6	36.5	32.2	709

Calculation

Reflecting material- Stainless steel

Time-10 am to 11 am

1) Time=10:10 to 10:20

a) Useful heat gain by water (Q_u)

$$Q_u = mc_p\Delta T$$

$$=0.049x4.186x10^{3}x\ (25.7\text{-}25.2)$$

$$=102.66\ \text{watt}$$

b) input solar energy (Q_i)

$$Q_i = A_a \times I$$

$$=1.5393x\frac{656+657}{2}$$

$$=987.45\text{watt}$$

c) Instantaneous efficiency(η_{inst})

$$\eta_{inst} = \frac{Q_u}{Q_i}$$

$$= \frac{102.66}{987.46}$$

$$\eta_{inst} = 9.61\%$$

Hourly efficiency (η_h)

$$=\frac{9.61+5.5+6.48+9+7.42}{5}$$

$$\eta_h = 7.60\%$$

Overall efficiency ($\eta_{overall}$)

$$=\frac{7.6+5.908+13.54+19.28+25.5+44.42+22.41}{7}$$

$$=19.80\%$$

Result Tables and Graph

Table 8. Result table for stainless steel (Time-10am-11am)

Time (Hr)	Useful heat gain by water (Watt)	Input solar energy(Watt)	Instantaneous efficiency (%)	Hourly efficiency (%)
10:10-10:20	102.66	987.46	9.61	7.60
10:20-10:30	61.54	1116	5.5	
10:30-10:40	82.06	1266	6.48	
10:40-10:50	102.58	1139	9	
10:50-11	82.06	1105	7.42	

Table 9. Result table for stainless steel (Time-11am-12pm)

Time (Hr)	Useful heat gain by water (Watt)	Input solar energy(Watt)	Instantaneous efficiency (%)	Hourly efficiency (%)
11:10-11:20	20.5	1251.45	1.63	5.908
11:20-11:30	82.06	1304.55	6.29	
11:30-11:40	164.13	1390.75	11.8	
11:40-11:50	61.54	1485.42	4.14	
12	61.54	1071.5	5.74	

Table-10. Result table for stainless steel (Time-12pm-1pm)

Time (Hr)	Useful heat gain by water (Watt)	Input solar energy(Watt)	Instantaneous efficiency (%)	Hourly efficiency (%)
12:10-12:20	266.71	1650.12	16.16	13.54
12:20-12:30	184.64	1607.79	11.48	
12:30-12:40	369.29	1601.64	23.05	
12:40-12:50	143.6	1630.18	8.60	
01:00	123.09	1456.17	8.45	

Table-11. Result table for stainless steel (Time-1pm-2pm)

Time (Hr)	Useful heat gain by water (Watt)	Input solar energy(Watt)	Instantaneous efficiency (%)	Hourly efficiency (%)
01:10-01:20	205.16	1603	12.79	19.28
01:20-01:30	328.26	1634.73	20.08	
01:30-01:40	328.26	1546.99	21.21	
01:40-01:50	328.6	1495.42	21.95	
02:00	287.22	1378.44	20.83	

Table 12. Result table for stainless steel (Time-2pm-3pm)

Time (Hr)	Useful heat gain by water (Watt)	Input solar energy(Watt)	Instantaneous efficiency (%)	Hourly efficiency (%)
02:10-02:20	164.13	1473.11	11.14	25.5
02:20-02:30	533.42	1480.8	36.02	
02:30-02:40	451.35	1349.2	33.45	
02:40-02:50	266.71	1226.05	21.75	
03:00	287.22	1146.77	25.04	

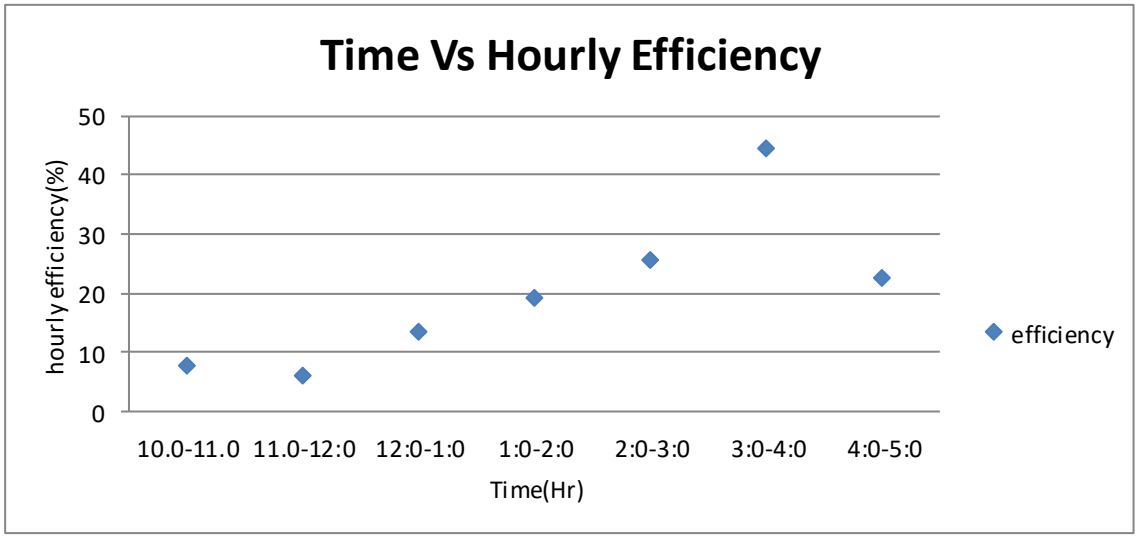
Table 13. Result table for stainless steel (Day-1 Time-3pm-4pm)

Time (Hr)	Useful heat gain by water (Watt)	Input solar energy(Watt)	Instantaneous efficiency (%)	Hourly efficiency (%)
03:10-03:20	243.25	740	32.85	44.42
03:20-03:30	590.5	959.7	52.3	
03:30-03:40	486.5	1066.7	45.6	
03:40-03:50	405.4	1113.6	36.4	
04:00	324.3	1329.18	24.39	

Table-14. Result table for stainless steel (Day-1 Time-4pm-5pm)

Time (Hr)	Useful heat gain by water (Watt)	Input solar energy(Watt)	Instantaneous efficiency (%)	Hourly efficiency (%)
04:10-04:20	123.0978	946.6695	13.00325	22.41
04:20-04:30	410.326	1254.53	32.70756	
04:30-04:40	205.163	1257.608	16.31375	
04:40-04:50	307.7445	997.4664	30.85262	
05:00	184.6467	962.8322	19.17745	

Graph Time vs. Hourly Efficiency



Graph. 1. Variation in hourly efficiency with time

The stainless steel reflector's hourly efficiency is depicted on a graph along with its diurnal change over time. The efficiency clearly increases starting at 10 am and reaches its highest value of 44.82 percent at 3.30 pm before abruptly decreasing after 3.30 pm, as can be seen in the above plot. It is as a result of an increase in sun intensity during that time.

CONCLUSION

Stainless steel was used for the experiments and performance evaluation of the parabolic solar dish collector in this work. Here, we looked at the usable heat gain as well as the instantaneous, hourly, and total efficiencies. When stainless steel is utilised as a reflector, the overall thermal efficiency is 19.86 percent.

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