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Performance Analysis of Copper Absorber Tube Parabolic Collector

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ABSTRACT---The solar parabolic trough collector technology is one of the most reliable technologies in the field of solar thermal. This is due to the fact that temperatures as high as 400^{o} C can be achieved using this technology. The energy development from these systems used for hot water production, process steam requirement, power generation and many more. Majorly they have wide applications in cooking. They are also used to generate steam at higher temperatures which is used to run a subsequent engine. In the present Paper, performance analysis of copper absorber tube parabolic collector is done for different parameters of the system such as Reflector sheet material, heat transfer fluid, Period of Sun Incidence at different levels the output responses such as Out Temperature of heat transfer fluid, Discharge, and Thermal Efficiency are recorded for each run. The optimization method S/N ratio analysis is applied for determining the optimal parameters level for better responses and the optimum results are confirmed experimentally

Keywords- parabolic trough collector, copper absorber tube, Taguchi Design of Experiment, S/N ratio analysis

I. INTRODUCTION

The worldwide requirement of energy is persistently increasing and makes it ineluctable to make the use of unconventional resources. The sun is one of the substantial energy sources that have the potential to fulfill this rising energy need. Sun is inexhaustible and cleaner source of energy. Solar thermal technology is inevitable in growth of the community as well as the nation. Also, it is important to the nation and to the Earth [1]. Sun is an enormous pool of clean energy and this clean power reaches earth in the form of its rays is known as Solar Energy. Solar energy is an abundant source of energy and is available in plenty. Conversion of these incoming solar radiations can be done directly or indirectly in other useful forms of energy as heat and electricity which can be utilized further as per the requirement of the mankind [3] .The sun is providing an incredible supply of solar energy for over 4 billion years. Solar energy was used by the ancient people to warm their homes and dry clothes but their uses were mostly primitive. Drastic increase in global oil prices, extensive use of fossil fuels, threatening rise in pollution and greenhouse effect have led a large number of countries around the globe to carry out extensive research in this area [7] . This parametric analysis on a parabolic trough collector is performed and is optimized by using taguchi S/N Ratio analysis.

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II. OVERALL SPECIFICATIONS OF THE SYSTEM

The specifications of solar parabolic trough collector system are given below

Table:I Overall Specifications of the system

component	Specification
Parabolic Reflector	
Length	2.000 m
Arc length	2.000 m
Depth	0.645 m
Focal length	0.340 m
Material	Aluminium Sheet and Glass Mirror
Absorber Tube	Copper with dia. 19.5mm
Working fluids	water and Brine solution
Storage Tank	1(Above the reflector sheet)
Different Meters	
Digital Thermometer	To measure Temperature

Fig.1 Parabolic Trough collector with Copper C101 as Absorber Tube

Experimental Procedure

Steps that were followed during the experimental investigation are as follows:

Step 1: cleaning of the reflecting surface in order to remove the accumulated dust.

Step 2: Setting and positioning the reflector according to the sun's position. Switching on the mechanism in order to supply water and running the system for 30 min prior to recording the first reading.

Step 3: The time gap between each reading is set to one hour. Flow rate of the heat transfer fluid at the beginning was kept constant to ensure proper reading. The discharge value is noted for every hour.

Step 4: The experiment on the system was started at 8:00 AM and the reading was taken from 11:00 AM by recording the data for every three hour.

Step 5: After all the required readings were taken the mechanism was switched off and the whole set up was covered.

Step 6: The same procedure was repeated by using glass mirror as reflector and readings were noted.

Likewise we have 8 combinations whose results were displayed in the Table: 3.

The experimental procedure as mentioned above was followed throughout the experimental investigation.

Design of Experiments using Taguchi Method:

Three parameters namely Period of Sun Incidence (POI), Reflector Sheet material, Heat Transfer fluid. L8 orthogonal array was formed based on the three parameters using mixed level design.

Table:II Parameters and their levels& Results

S.no	Process Parameters	Level 1	Level 2	Level 3	Level 4
1	Period of Sun Incidence	8 a.m-11a.m	11am- 1 p.m	1p.m - 3pm	3p.m - 6p.m
2	Reflector sheet Material	Al sheet	GM	-	-
3	Heat ransfer fluid	Water	Brine solution	-	-

Table:III Experimental results and response data

A	*B*	*C*	*Output Temp (oC)*	*Discharge (lt/hr)*	*Thermal Efficiency (%)*
8am -11am	Al sheet	Water	59.9	18.1	87.19
8am -11am	GM	BS	66.4	18.7	98.95
11am-01 pm	Al sheet	Water	60.8	19.4	90.00
11am-01 pm	GM	BS	79.6	15.7	99.89
01pm-03pm	Al sheet	BS	51.3	18.4	60.30
01pm - 3pm	GM	Water	50.2	17.2	56.90

Note:- From the above table we have

A- POI; B – Reflector and C – Heat Transfer fluid

POI - Period of Sun Incidence.

GM -Glass Mirror as Reflector.

BS-Brine Solution as Heat Transfer fluid

Analysis of Output Temperature:

From the Figure 2, the optimal process parameter combinations for obtaining better output temperature are as follows.

Optimum process parameters

POI - Period of Sun Incidence (A) – 11am- 1 pm at level 2

Medium used Heat Transfer fluid– Brine Solution at level 2

Reflector sheet material – Gm at level 2

Moreover from the Table IV, it also revealed that POI - Period of Sun Incidence (Rank 1) is the most influenced parameter for output temperature

Table VI: S/N ratio rank analysis for Output Temperature

Level	A	B	C
1	63.15	56.25	55.57
2	70.20	61.90	62.58
3	50.75	-	-
4	52.20	-	-
Delta	19.45	5.65	7.00
Rank	1	3	2

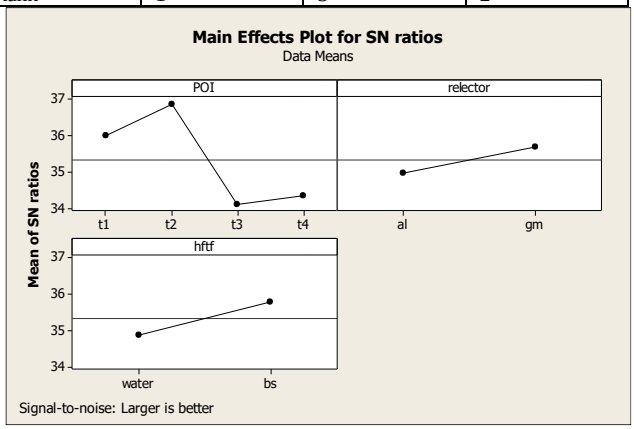

Figure 2: Main effects plot of the S/N ratio for Output Temperature

Analysis of Discharge:

From the Figure 3 the optimal process parameter combinations for obtaining better Discharge are as follows.

Optimum process parameters

POI - Period of Sun Incidence (A) – 1p.m to3pm at level 3,

Reflector sheet material–Al at level 1

Medium used Heat Transfer fluid – Brine Solution at level 2.

Moreover from the Table V, it also revealed that POI - Period of Sun Incidence (Rank 1) is the most influenced parameter for output Discharge (lt/hr).

Table V: S/N ratio rank analysis for Discharge

Level	A	B	C
1	25.30	25.35	25.31
2	24.84	24.92	24.96
3	25.00	-	-
4	25.41	-	-
Delta	0.57	0.43	0.35
Rank	1	2	3

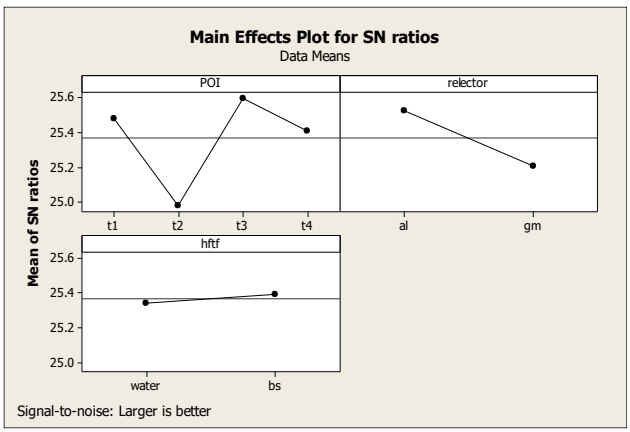

Figure 3: Main effects plot of the S/N ratio for Discharge

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Analysis of Thermal efficiency:

From the Figure 5.1, the optimal process parameter combinations for obtaining Thermal efficiency are as follows.

Optimum process parameters

POI - Period of Sun Incidence (A) – 11am- 1 pm level 2,
Medium used Heat Transfer fluid–GM at level 2
Reflector sheet material – Brine Solution at level 1.

Moreover from the Table IV, it also revealed that POI - Period of Sun Incidence (Rank 1) is the most influenced parameter for output Thermal efficiency.

Table VI: S/N ratio rank analysis for Thermal efficiency

Level	A	B	C
1	42.38	50.18	53.84
2	60.90	52.89	49.23
3	44.66	-	-
4	58.21	-	-
Delta	18.51	2.70	4.60
Rank	1	3	2

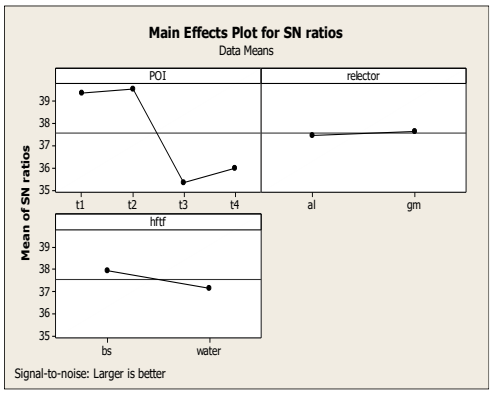

Figure 4: Main effects plot of the S/N ratio for Thermal efficiency

III. CONCLUSIONS

In this paper performance analysis of copper absorber tube parabolic collector is done for different parameters of the system such as Reflector sheet material, heat transfer fluid, Period of Sun Incidence at different levels. The test data are analyzed using S/N ratio analysis and the optimum influential parameter combinations have been identified and confirmed experimentally are conducted.

The following conclusions have been drawn from this work.

1. The highest temperature reached in a during the time between 11:00 a.m. to 1:00 p.m. This time must be utilised by organisations which depend on solar power like utilizing more number of collectors during the peak time in order to generate more amount of steam.

2. It is absorbed that Brine Solution attains some higher values of temperature than that of normal water. Hence solar parabolic collector has wide usage in areas having salt water. The absorber tubes used in this experiment are repellent towards formation of scales. So it is preferable to use this combination for Salt water as well as for fresh water.

3. Best combination of parameters obtained from S/n ratio analysis

For maximum temperature:

- Temperature : 79.6°C
- Discharge : 15.7 lit/hr.
- Thermal Efficiency : 99.89%
- GM -Glass Mirror as
- BS-Brine Solution as Heat Transfer fluid.

For maximum discharge

- Temperature : 60.8°C
- Discharge : 19.4lit/hr.
- Thermal Efficiency : 90.00%
- Reflector Al sheet
- Water Solution Heat Transfer fluid.

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