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Study and optimization of thermal parameters of parabolic trough power plant used in the site of Ain-Defla

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Abstract

Solar energy is one of the most attractive renewable energy sources due to its abundance in our country. However, despite the specificities of the region of Ain-Defla that can be used to reduce the use can't be supported by the state. In this case, the contribution of solar energy could effectively contribute in solving some energy problems. Current systems are mainly based on the technology known as the "parabolic trough power plant" which uses a long rectangular mirror and a parabolic trough. The solar rays are reflected by the mirror to converge on the tube which is placed at the focal line of a parabolic trough concentrator; this system has an excellent power generation, it's non-polluting, and silent. In that respect, this research aims to study the performance improvement of a parabolic trough. Several techniques exist to ensure the high temperature at the outlet, for the optimization is compatible with the software called "Engineering equation Solver" (EES).

Keywords: parabolic trough power plant, solar thermal, thermal parameters.

1. Introduction:

For a Clean Environment should use solar energy. In this study we use solar energy where we take a parabolic trough power plant's solar field consists of a large, modular array of single-axis-tracking parabolic trough solar collectors. Many parallel rows of these solar collectors span across the solar field, usually aligned on a north-south horizontal axis, and we apply it to weather conditions the city of Ain-Defla[1], Algeria (Cf. Photo1).

Photo 1: Map of Algeria highlighting Aïn-Defla

[1]*Aïn-Defla is a district of Ain-Defla the wilaya (province) in northern Algeria. Coordinates: 36°19′N 2°10′E*

Sources :http://www.elwatan.com/images/2010/10/22/eco_148145_465x348.jpg

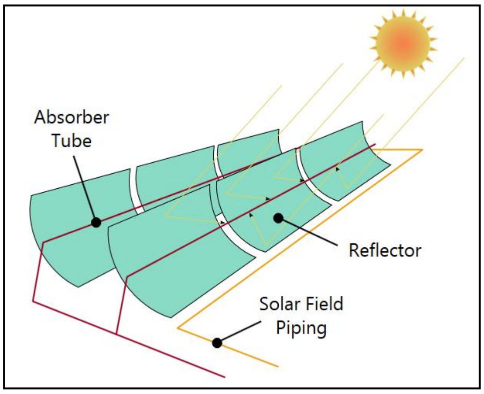

Fig. 1: A schematic solar collector assembly [1].

2. Linear regression heat loss model

Determine the following functional form of the heat loss equation as a function of temperature and DNI [5-2]:

$$HL = a_0 + a_1 T + a_2 T^2 + a_3 T^3 + DNI(b_0 + b_1 T^2) \qquad (1)$$

where:

HL: Heat loss from the outermost surface of the receiver, per unit length [W/m]
T: Bulk fluid temperature [°C]
DNI: Direct normal insolation [W/m^2]
a, b: Coefficients (see Table 1)

Table 1
Coefficients for Receiver Heat Loss [5]

Parameter	Value
a_0	-2.247372E+01
a_1	8.374490E-01
a_2	0.00
a_3	4.620143E-06
b_0	6.983190E-02
b_1	9.312703E-08

3. Heat transfer fluid energy gain and temperature rise:

The net energy collected by the heat transfer fluid over the field, per unit aperture area [W/m^2], is the difference between the heat absorbed into the fluid by the absorber tubes and the sum of heat loss from the receivers and heat loss from the piping to and from the solar field [2]:

$$Qc_{ol}=Q_{abs}-(Re_{+}S_f \qquad (2)$$

where:

$$R_e = \sum_{i=1}^{numHCEType} HCEFrac_i \cdot \frac{HL_{f,i}}{Width}$$

$$S_f = 0.01693\Delta T - 0.0001683\Delta T^2 + 6.78.10^{-7}\Delta T^3$$

S_f is expressed per unit area of solar field aperture [W/m^2], and T [°C] is the difference between the average field temperature and the ambient air temperature [3]:

$$\Delta T = \frac{T_{f,out} + T_{f,inl}}{2} - T_{amb} \qquad (3)$$

4. Results and discussion

4.1. Results within a year

Table 2
Result within a year of Parabolic Trough Solar for inlet temperature and DNI.

Months	T_{amb} [C°]	$T_{fieldoutlet}$ [C°]	DNI [KWh/m^2]	P_{abs}
January	10.8	259.5	122	272.5
February	11.8	233.3	103	230.1
March	14.8	294.5	147	328.4
April	16.8	305.7	155	346.2
May	21.1	325.1	169	377.5
Jun	26.3	407.3	237	529.4
July	29.3	450.7	276	616.5
August	29.0	397.3	227	507.1
Septembre	26.9	332.5	173	386.5
October	21.5	315.2	161	359.6
November	15.2	261.3	122	272.5
December	12.1	227.7	099	221.2

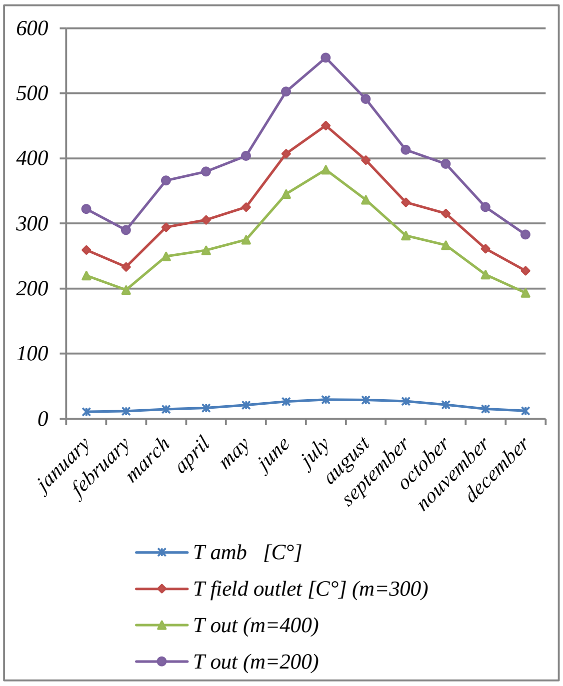

Fig. 2: The variation in outlet temperature with the mass flow.

Table 3
Result during the day of Parabolic Trough Solar for inlet temperature and DNI of 1st January 2014.

Time	T amb	DNI	T out 1rt jan 44
00:00-01:00	5.80000019	0	60.96
01:00-02:00	9.875	0	62.19
02:00-03:00	13.000001	0	63.12
03:00-04:00	12.7937498	0	63.06
04:00-05:00	12.6437502	0	63.02
05:00-06:00	12.5500002	0	62.99
06:00-07:00	12.4499998	0	62.96
07:00-08:00	12.3500004	0	62.93
08:00-09:00	12.2835941	0	62.91
09:00-10:00	12.3351564	0	62.93
10:00-11:00	13.7786188	400	356.4
11:00-12:00	15.7609654	787	545.5
12:00-13:00	17.5273819	797	551.9
13:00-14:00	18.7455368	717	518
14:00-15:00	19.5955353	683	503.1
15:00-16:00	20.0607147	645	485.8
16:00-17:00	20.0527782	540	434.7
17:00-18:00	19.6131306	283	288
18:00-19:00	18.5590916	0	64.73
19:00-20:00	17.6999989	0	64.48
20:00-21:00	17.1000004	0	64.31
21:00-22:00	16.5	0	64.14
22:00-23:00	15.9000006	0	63.97
23:00-00:00	15.3000002	0	63.79

It is noted that the outlet temperature increases with increasing flow and is up to a maximum from May to September. This is because the value of DNI cruelty, and in the rest of the months, the outlet temperature ranging between 200°C and 350°C.

4.2.1. Results during the day

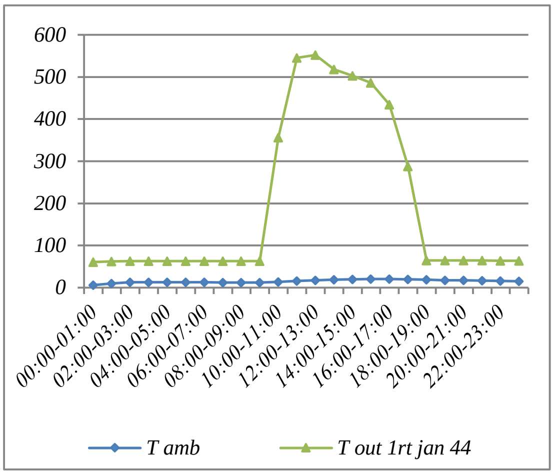

Fig. 3: Variation in outlet temperature with the inlet temperature of the day 1st January 2014.

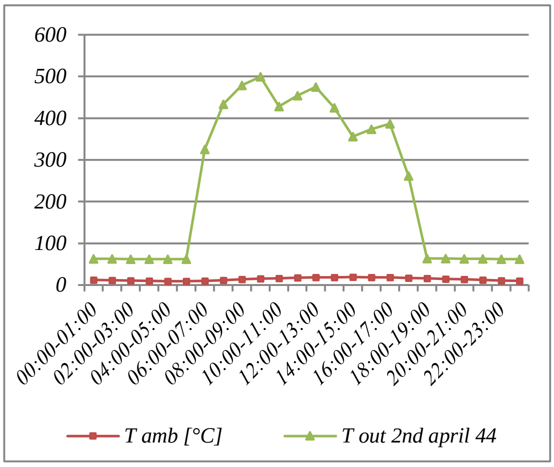

Fig. 4: Variation in outlet temperature with the inlet temperature of the day 2nd April 2014

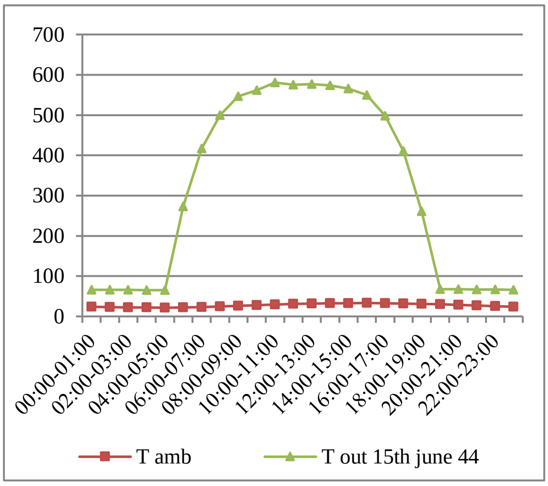

Fig. 5: Variation in outlet temperature with the inlet temperature of 15th June 2014 day

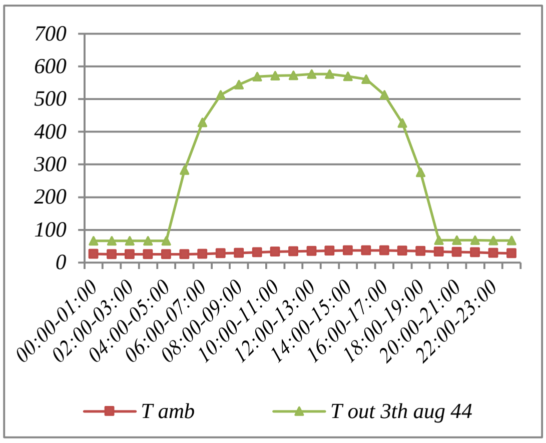

Fig. 6: Variation in outlet temperature with the inlet temperature of the day 3th August 2014

We note that the outlet temperature takes the greatest value from 09:00 to 17:00.

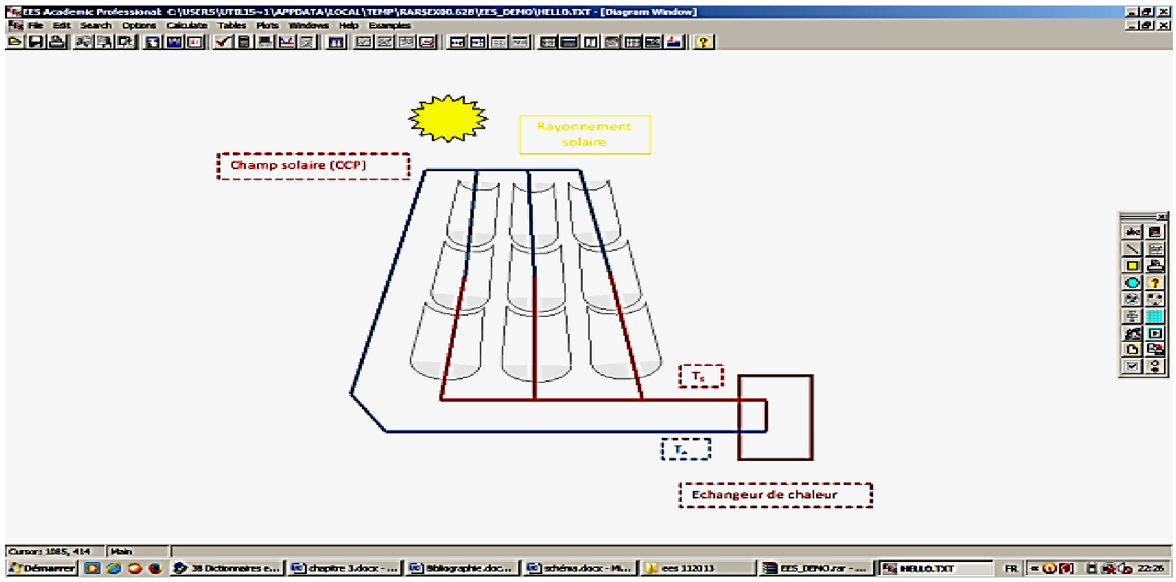

Fig. 7: Diagram of the installation of a parabolic trough collector [4].

5. Conclusions:

In this theoretical study, we conclude that the use of solar energy in the city of AinDefla is possible and successful, the parabolic trough linear receiver, also called a heat collection element (HCE), is one of the primary reasons for the high efficiency of the original Luz parabolic trough collector design. The purpose of this study is to use the results obtained in various areas, Electric power generation.

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