Sirte University Scientific Journal Vol. 14, No. 1 (2024) 60-65

Sirte University Scientific Journal (SUSJ)

Journal home page: http://journal.su.edu.ly/index.php/SUSJ/index

DOI: 10.37375/ susj.v14i1.2803

The effect of Solar Systems Connecting on water heating production

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DOI: 10.37375/susj.v14i1.2803

ARTICLE INFO:

Received 15 February 2024.
Accepted 25 May 2024.
Available online 01 June 2024.

Keywords: *Solar collector testing; energy output and solar system connections*

A B S T R A C T

The study is based on taking advantage of high solar radiation the possibility of applying parabolic cutting technology to produce steam in various thermal uses and proposes to captures a large portion of the diffuse solar radiation in addition to the direct component with a concentration rate of up to 92%. A computational model has been developed to assist in the design of two solar parabolic dishes. The solar parabolic dish was fabricated at Sirte University; an experimental investigation was carried out to verify its operation under outdoor test conditions. The glass dish test was carried out on 10^{th} June 2020, from morning 07:00 to 17:00. Under this condition, measure the maximum outlet temperature of 96.7 ^{0}C, and solar radiation was 1005 W/m2. The aluminum dish test was carried out on the 11^{th} june 2020, from 08:00 to 17:00. Under this condition, measure the maximum outlet temperature of 78˚C was reached with radiation 1050.5 W/m^2. The absorber tube is a pipe placed at the focal line of each dish. The parallel and series connection configuration of the system investigated to evaluate the arrangement type's effect on the thermal performance. It has been found that the thermal performance in series connection is higher than the parallel connection; it takes longer time than the parallel connection to absorb the heat. The maximum outlet temperature for series and parallel connections are 99 ^{0}C and 93 ^{0}C respectively when flow rate 3 LPM.

Nomenclature

Symbol	Description	Unit
ϕ	Rim angle	Degree
f	Focal length	Cm
A_a	Aperture Area	Mm
A_f	Focus area	Mm
D_a	Reflector Aperture	Mm
D_r	Receiver diameter	Mm
Q	Thermal heat gained	J
t	Time	S
m	Mass	Kg
c	Specific heat capacity	J/kg-˚C
ΔT	Temperature difference	˚C
Tout	Outlet water	˚C
Tin	Inlet water temperature	˚C
Hv	Heat of vaporization	J/kg

Introduction

Traditional energy (electrical energy) is currently relied upon to obtain hot water and for various heating purposes, although great efforts have been made to develop the energy sector, due to the increasingly large

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demand. Thus, Libya is still in the growth stage (development stage), which requires a lot of energy demands. As a result of the expansion of construction, infrastructure, industrial and others. The city of Sirte is located in the center of northern Libya (latitude 31.19 degrees north), where it can obtain enough sunlight throughout the year (330 days) and has ideal geographical and climatic advantages that greatly help in the production of solar energy. This project studies the possibility of applying solar thermal energy that can be implemented in the city of Sirte instead of relying entirely on polluting and expensive traditional energy, switching to clean and cheap solar energy. Data, technical information, hot water uses in service, climate data, and auxiliary energy options for the city of Sirte are carefully collected and documented, and accordingly a design methodology is proposed to study steam production. Two parabolic solar dishes can bdesigned, built, evaluated and operated to generate hot water and steam. Some modifications are to improve process heat gain applications using parabolic solar dishes, and the method of passing water through a series or parallel connection system .should be prepared according to APA, 7th ed.,Cite references in the text in alphabetical order first, and chronological order second Subsection heading (Headings: Please use no more than three levels of displayed head

System setup and Methods

The system consists of two reflecting dishes, with two absorbing copper coiled tubes (receivers). The two absorber tubes placed at the focal point of the parabolic dishes. Water was used as heat transfer fluid (HTF), two boilers each has 7 litters capacity.

The receiver for this system acts as an absorption unit and heat exchanger. It consists of a copper tube 5.0 meters long and 1.27 cm in diameter. It is twisted into a coil and installed in a small, round, thin steel container with a diameter of 25 cm. A 4.0 cm thick plaster layer was made below the copper coil receiver and the lower cavity was filled with polyurethane foam to reduce heat loss to the receiver and retain the heat gain thus increasing efficiency. Finally, the receiver was placed in the focal point at the focus point. For testing and cost reduction, the sun was tracked manually every 10 minutes.

Geometric concentration ratio (C): It is the ratio of collector's aperture area (A_a) and focus area (A_f).[7].

$$C = \frac{A_a}{A_f} \qquad (1)$$

Solar power gained of the parabolic concentrator is the thermal energy gained per unit time is given by the following equation:

$$P = \frac{Q}{t} \qquad (2)$$

Thermal Heat Gain $Q = m * Cp * \Delta T$

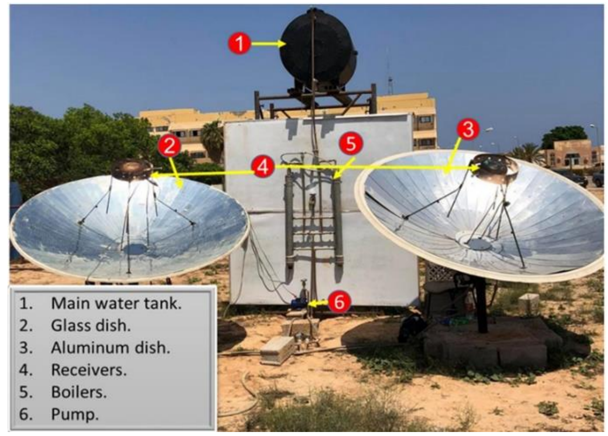

Figure 1: System components

Table 1: Geometrical and Technical Specification of (PDSC)

Parameter	Symbol	Value
Reflector Aperture	D_a	240 cm
Reflector depth	H	45cm
Rim Angle	ϕ	70°
Focal Distance	f	83 cm
Reflector Aperture	A_a	4.50 m^2
Focus Area	A_f	490 cm^2
Absorber(receiver)	D_r	1.27 cm
Concentrator Ratio	C.R_g	92
Mirror Reflectance	M.R %	80 - 95 %
Water Flow Rate	WFR	1.0 – 4.0 L
Boiler Capacity	B.C	7.0 liter
Power Of Circulation	P	110 Watt
Heat Transfer Fluid	HTF	Water
Heat Exchanger	HET	360 cm-Long

Individual, Series and Parallel Connections

The main components of the whole system (collector – receiver – pump – boiler) were connected with PPR pipes , and the system is filled with water which was used as a heat transfer fluid and the water was circulated in a closed loop by means of 0.5 HP pump. The performance of the reflecting collectors was tested by connecting each of the two collectors (Aluminum and Glass mirror) individually.

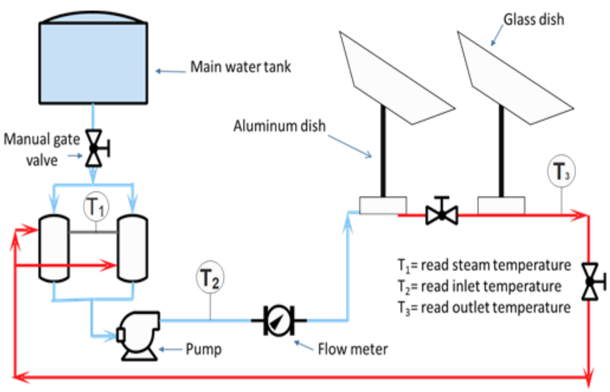

Figure 2: schematic diagram of series connection

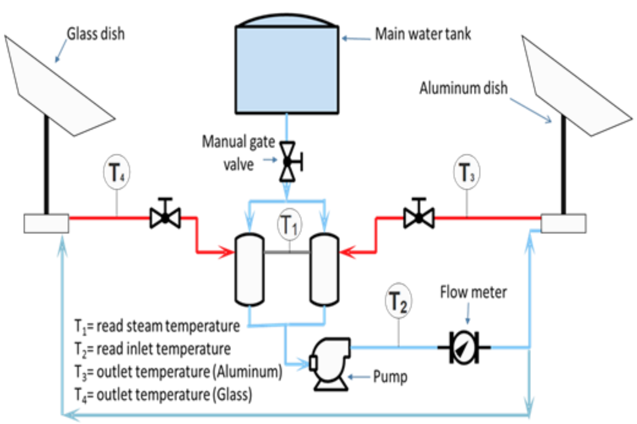

Figure 3: schematic diagram of parallel connection

Results

Glass Dish with individual connection
Date: 10/06/2020, Flow rate: 3L/min

Table 2: Results data for day 3

Time	Inlet Temperature (ºC)	Outlet Temperature (ºC)	Delta T (ºC)	Radiation (W/m²)	Energy output (Q=m*Cp*ΔT) (J)
07:00	24	24	0	800.5	0
07:30	28	28	0	835.8	0
08:00	34	35	1	867	12567
08:30	51	56	5	888	62835
09:00	68	72	4	920	50268
09:30	74	79	5	943	62835
10:00	82	87	5	966	62835
10:30	86	90	4	981	50268
11:00	86	92	5	1005	62835
11:30	88	92	4	955	50268
12:00	85	89	4	1030	50268
12:30	84	88	4	1032	50268
13:00	85	91	6	1040	75402
13:30	87	91	4	1049	50268
14:00	87	93	6	1051	75402
14:30	91	96.7	5	1066	62835
15:00	87	93	6	1040	75402
15:30	85	87	3	1031	37701
16:00	80	74	6	1040	75402
16:30	72	78	6	1020	75402
17:00	64	69	5	987	62835

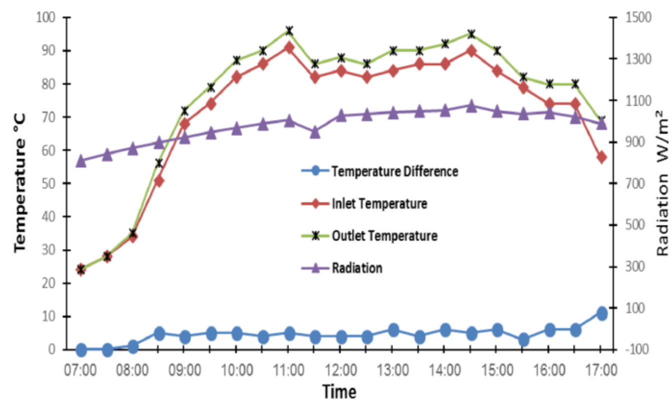

Figure 5: The glass dish and variations in day 1

Day two, Aluminum Dish with individual connection
Date: 11/06/2020, Flow rate: 3/min

Table 3: Results data for day 3

Time	Inlet Temperature (ºC)	Outlet Temperature (ºC)	Delta T (ºC)	Radiation (W/m²)	Energy output (Q=m*Cp*ΔT) (J)
07:	26	26	0	855	0
07:	27	30	3	877	37701
08:	32	34	2	880	25134
08:	37	40	3	897	37701
09:	54	58	4	923	50268
09:	60	64	4	940	50268
10:	63	68	5	971.9	62835
10:	67	71	4	982.2	50268
11:	68	73	5	1035	62835
11:	70	76	6	1055	75402
12:	68	71	3	1004	37701
12:	64	69	5	999	62835
13:	66	72	6	1007	75402
13:	72	76	4	1044	50268
14:	70	78	8	1049	100536

14:	72	76	4	1066	50268
15:	64	68	4	1051	50268
15:	60	62	2	1032	25134
16:	58	60	2	1020	25134
16:	55	60	5	989	62835
17:	56	61	5	980	62835

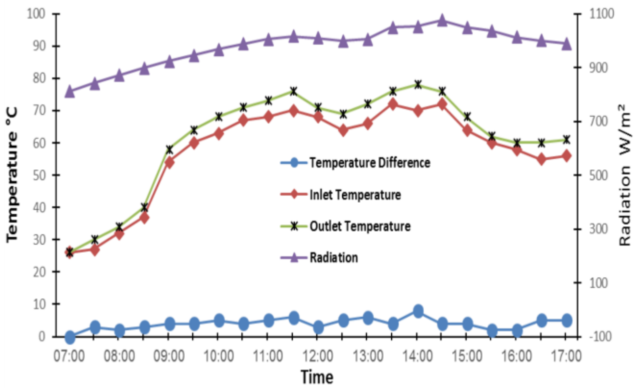

Figure 5: The aluminum dish and variations in day 1

Connecting the system in parallel in day 3.
Date: 1/08/2020.
Flow rate: 3 LPM

Table 4: Results data for day 3

Time	Radiation (W/m^2)	Inlet T_{alum} (°C)	Outlet T_{alum} (°C)	Delta T °C	Q(Al) = (m C_p ΔT)	Inlet T (glass)	Outlet T (glass)	Delta T	Q(Al) = (m C_p ΔT)
07:00	794.1	26	29	3	37701	22	22	0	0
07:30	833	27	30	3	37701	26	26	0	0
08:00	852	27	31	4	50268	32	33	1	12567
08:30	871.8	34	39	5	62835	49	53	4	50268
09:00	904.2	37	41	4	50268	66	69	3	37701
09:30	927	51	56	5	62835	72	76	4	5026
10:00	956	50	55	5	62835	80	84	4	5026
10:30	977.9	54	59	5	62835	84	87	3	3770
11:00	990.5	47	52	5	62835	89	93	4	50268
11:30	1020.3	44	49	5	62835	80	83	3	37701
12:00	1040	50	55	5	62835	82	85	3	37701
12:30	1029	55	61	6	75402	80	83	3	3770
13:00	1030.3	40	45	5	62835	82	87	5	6283
13:30	1030.1	60	65	5	62835	84	87	3	37701
14:00	1033	58	64	6	75402	84	89	5	62835
14:30	1055	40	45	5	62835	88	92	4	50268
15:00	1043	38	43	5	62835	82	87	5	6283
15:30	1040.9	45	50	5	62835	77	79	2	2513
16:00	1030.2	50	55	5	62835	72	77	5	6283
16:30	1002	48	53	5	62835	72	77	5	62835
17:00	987	26	29	3	37701	62	66	4	50268

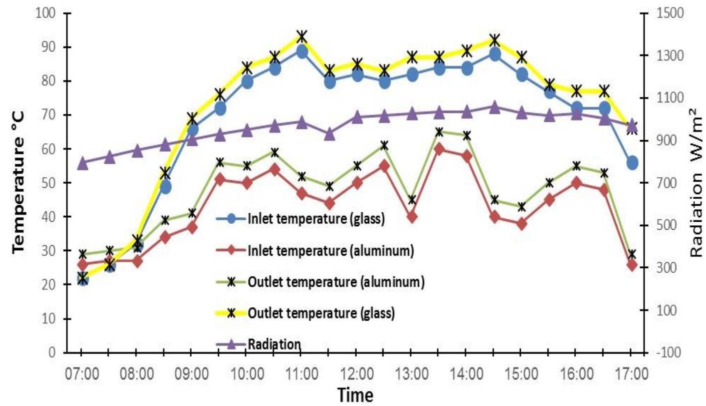

Figure 5: Variations with time for parallel connection in day 3

Connecting the system in series in day 4.
Date: 02/08/2020.
Flow rate: 3 LPM

Table 5: Results data for day 4

Time	Inlet Temperature (oC)	Outlet Temperature (oC)	Temperature Difference (ΔT)	Radiation (W/m2)	Q=mCpΔT w
07:00	24	29	5	814	62835
07:30	26	33	7	844	87969
08:00	32	38	6	878	75402
08:30	41	48	7	892	87969
09:00	57	65	8	922.6	100536
09:30	76	83	7	950.1	87969
10:00	89	96	7	964	87969
10:30	91	98	7	972	87969

11:00	91	98	7	1003	87969
11:30	92	99	7	1010	87969
12:00	92	99	7	1011	87969
12:30	92	98	6	997	75402
13:00	91	98	7	1006	87969
13:30	91	98	7	1046	87969
14:00	91	98	7	1050	87969
14:30	89	97	8	1031	100536
15:00	88	95	7	1049	87969
15:30	84	91	7	1029.9	87969
16:00	83	90	7	1019	87969
16:30	81	88	7	998	87969
17:00	78	85	7	988.9	87969

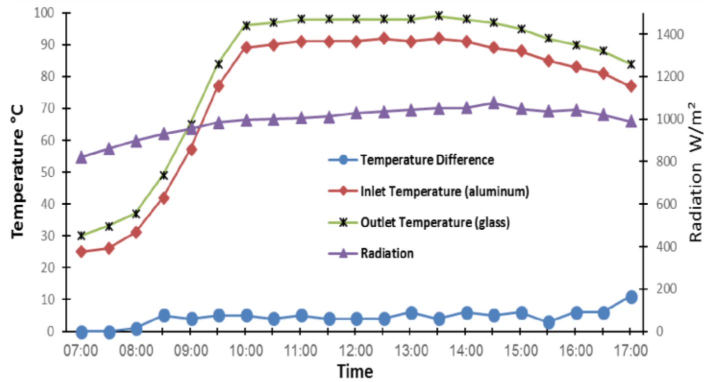

Figure 6: Variations with time for series connection in day 4

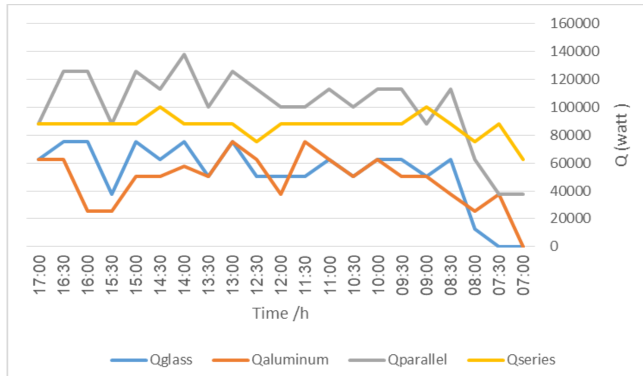

Figure 6: Variations Q with time for different connection.

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