Performance investigation of a two reflector box type Solar cooker with a finned absorber plate

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Abstract:

Energy being a necessary element in the fields of industry, agriculture, communication, transport and other sectors, the demand for it is growing manifold and the energy sources are becoming scarce and costlier. Solar energy is one of the most ancient sources which is easily available and the root for almost all fossil and renewable types. Special devices have been used for benefiting from the solar and other renewable energy types. This paper presents study; a box type solar cooker was designed, fabricated and tested. In this research author used finned absorber plate inside bottom surface of solar cooker and the top cover (Glazing) is tilted at 23˚ corresponding to the latitude of Jabalpur (the location of the test site). To provide the tilt, the height of the back side will made 25.47 cm while it will made 10 cm for the front one. The results of the experimental investigation have been rigorously analyses and showed that the cooking power of a two reflector box type Solar cooker with a finned absorber plate is 147.24 W and box-type solar cooker is 119.20 W. So cooking power was increased 23%. The time required for heating water up to boiling temperature in both box-type solar cookers was reduced with about 19% when a finned absorber plate was used.

Keywords: solar cooker, two reflector mirrors, Finned Absorber Plate; Latitude angle.

1. Introduction:

Solar cookers of various types were the subject of several theoretical and experimental studies all over the world. A. Harmim et al [1] the results of the experimental investigation have been rigorously analyses and showed that the stagnation temperature for box-type solar cooker equipped with a finned absorber plate was about 7% more than box-type solar cooker equipped with an ordinary absorber plate. The time required for heating water up to boiling temperature in both box-type solar cookers was reduced with about 12%when a finned absorber plate was used. The review covers a historic overview of solar cooking technology, detailed description of various types of solar cookers, geometry parameters affecting performance of solar cookers such as booster mirrors, glazing, absorber plate, cooking pots, heat storage materials and insulation. A.V.Narasimha Rao et al [2] have investigated the effect of keeping the cooking vessel on lugs and also a cylindrical cooking vessel with central annular cavity; they showed by experiments that the cooking vessel with central cavity improves effective heat transfer surface. A. Saxena et al [3] talk to about lot of research work has been carried out in recent past years in the world which clearly shown the utilization of solar energy towards the greatest needs of mankind obviously solar cooking, fuel saving, non-polluting environment and to save and produce electricity. Arezki Harmim et al. [4] have proposed a new shape for the cooking vessel. It is an ordinary cylindrical vessel by which external side surface is provided with rectangular fins along its circumference. Avala raji reddy et al [5] The mathematical model considers a double glazed hot box type solar cooker loaded with two different types of vessels, kept either on the floor of the cooker or on lugs. The performance of the cooking vessel with a central cylindrical cavity is compared with that of a conventional cylindrical cooking vessel. The average improvement of performance of the vessel with a central cylindrical cavity kept on lugs is found to be 5.9% and 2.4% more than that of a conventional cylindrical vessel on the floor and on lugs, respectively. . Negi and Purohit [6] conducted an experimental study of a box-type solar cooker with two non-tracking planar reflectors to enhance solar radiation in the box of the cooker. Amer [7] developed a double exposure box-type solar cooker; in such design the absorber is exposed to solar radiation from the top and the bottom sides. E. Cuce et al [8] is performed in a thematic way in order to allow an easier comparison,

discussion and evaluation of the findings obtained by researchers, especially on parameters affecting the performance of solar cookers. . H.-M. Yeh et al [9] A design for inserting an absorbing plate to divide the air duct into two channels for double-flow operation in solar air heaters with fins attached over and under the absorbing plate has been investigate .M.E.V. da Silva et al [10] presents the general types of solar cookers, theirs basic Characteristics and experimental procedures to test the different types of solar cookers .and talk to about the cooking power. M.A. Karim et al [11] in this study, flat plate, finned and v-corrugated air heaters were investigated both experimentally and theoretically. Results showed that the v-corrugated collector is 10–15 and 5–11% more efficient in single pass and double pass modes, respectively, compared to flat plate collectors. Nahar [12] investigated experimentally the thermal analysis of a double reflector box-type solar cooker with transparent insulation materiel. Kariuki Nyahoro et al [13] the block is enclosed in uniform layer of insulation except where there are cavities on the top and bottom surfaces to allow heating of a pot from storage and heating of the storage by solar radiation. A paraboloidal concentrator focuses solar radiation through a secondary reflector onto a central circular zone of the storage block through the cavity in the insulation. The storage is charged for a set period of time and heat is subsequently discharged to a pot of water. P.-W. Li et al. [14] developed for a solar stove heat collection system which uses a giant Fresnel lens. The results of the analysis have been incorporated into the control algorithm which has been implemented in the control system of a prototype solar stove which successfully demonstrated the predicted efficient solar tracking. A review of solar cookers was made by Muthusivagami et al. [15]. S. Kumar [16] presents a simple test procedure for determination of design parameters to predict the thermal performance of a box-type solar cooker. Subodh Kumar [17] the paper presents a simple test procedure for determination of design parameters to predict the thermal performance of a box-type solar cooker. A series of out-door experiments were performed on the double-glazed solar cooker of aperture area 0.245 m2 with a fiber body to obtain two figures of merit, F1 and F2. Suhail Zaki Farooqui [18] presented a novel mechanism for one-dimensional tracking of box type solar cookers along the azimuth has been reported in this paper. The proposed mechanism does not require any external power source, as the required tracking energy is drawn from the gravitational potential energy stored in a spring's. Xia et al [19] are composed of two symmetrical off-axis concentrators and inclined flat reflectors. When the two sides' focal spots just coincide, the concentrated flux distribution presents uniform in the extreme.

2. Description of the solar cookers:

This simple box type solar cooker consists mainly of an outer box, with and without finned absorber plate and glass cover (glazing) fitted at particular latitude angle 23 (at Jabalpur). The gap between the box and the absorber plate is filled with glass wool insulation. Box type solar cookers will be constructed using locally available materials as well as local technical assistance. The three internal lateral sides are covered by aluminum foil and on the opposed side to the aperture area a mirror of 62 cm by 62cm is fixed by screws. we shall performed a comparatively experiment simple solar cooker and second time use two reflector mirror as well as finned absorber plate. the absorber plate is made of aluminum painted black. Its upper surface is provided with Fins. Fins have a length of 5 cm; they are spaced at 4 cm. The attached fins on the absorber plate increase its temperature by radiative absorptance due to different multiple reflections. The temperature improvement of the interior hot air is obtained by the increase in the convective heat transfer plate air surface [1]. The temperature of the absorber plate, temperature of the internal hot air measured at the center of the internal cooker volume. The important parts of a hot box solar cooker include; a) outer box: the outer box of a solar heater is generally made of galvanized iron. Inner heating Box is made of aluminum sheets. The inner box is slightly smaller than the outer box. It is coated with black paint so as to easily absorb solar radiation and transfer the heat to the heating (cooking) pots. The insulating material should be free from volatile materials. Reflectors used in the solar cooker to increase the radiation input on the absorbing space and fixed on the inner side of the main cover of the box. They will reflect the radiation entering the box directly to the container and helps to quicken the cooking process by raising the inside temperature of the cooker. A glass lid covers the inner box or tray. It is slightly larger than the inner box and used finned absorber plate inside bottom surface of solar cooker and The top cover (Glazing) is tilted at 23° corresponding to the latitude of Jabalpur (the location of the test site). A rubber strip is affixed on the edges of the frame to prevent any heat leakage. the heating container is made of aluminum. These pots are also painted black on the outer surface so that they also absorb solar radiation directly. Four thermocouples at different locations were installed on the solar cooker. These locations are: a) upper surface of glass cover, b) lower surface of glass cover c) water temperature inside the pot and d) absorber plate temperature.

Fig.1.Photographofthefinnedabsorber plate

Fig.2 photograph of Experimental setup

In this setup we used two reflectors; both are having 3 mm thickness. A glass cover made with used two glasses whose have a thickness 4 mm and spacing between them 1.5 cm. For the first box-type solar cooker, the absorber tray consists of an aluminum sheet painted black of a surface of 30 cm by 30cm and 0.08 cm thickness. For the second one, the absorber plate surface is provided with fins made of aluminium painted black. Fins are of rectangular constant cross section (50 cm by 0.08 cm) and have a length of 5 cm; they are spaced at 4 cm. Photograph of this absorber plate is shown in Fig. 1. We used pots of 19 cm diameter and height 60 mm.

2.1 Instrumentation:

For each cooker, the temperature of the absorber plate, the temperature of water in each cooking vessel is also measured by the same type of thermocouple introduced through a small hole at the lid center. Ambient temperature and wind speed measurements were taken by euro lab mini anemometer (accuracy ±3%, range 0.1-25.00 m/s and resolution 0.01 m/s) with thermometer (range 0-50^{o} C). Solar intensity radiation was measured by precision Pyranometer. A Digital processing meter was used to show the output voltage in mV. mV convert to degree centigrade ,calibrated with the help of hypsometer and also convert to w/m^{2}. The temperature measurements were carried out using K type thermocouple range from 0-1100 ^{o}C.

3. Experimental study:

The principal objective of this work is a preliminary testing of a two reflector box type solar cooker equipped with a finned absorber plate. The finned absorber enhances the rate of heat transfer to the air inside the cooker. A box-type solar cookers have been designed and fabricated; the first one equipped with an ordinary absorber plate and the second one equipped with a finned absorber plate and two reflector .The principal goal of this experimental study is not the presentation of a simple box-type solar cooker whose time of cooking is rather long because it is not equipped with reflectors, but it is about possibility of reducing the cooking time of solar cookers with the help of a simple modification on the absorber plate geometry. A comparative experimental test of heating power of the solar cookers was carried out during the successive days from the 19th and 25st April 2014. Each experiment starts from 9:30 am in the morning .The electrical and electronic parts were tested and calibrated before being used on the various places on both type solar cookers. The experimental work was fully carried out at mechanical engineering Department, Jabalpur engineering college Jabalpur (M.P.) India. First one, we have performed experimental test on conventional solar cooker with load of 1 kg of water takes in pots. Then takes the readings and same procedure performed of two reflectors box type solar cooker with a finned absorber plate without reflectors and finned absorber plate. The temperature probe of the thermocouple was placed in one of the cooking pots with the measuring tip submerged in the water. The temperature probe lead was sealed where it left the pot and the cooker. Then the

entire solar cooker was placed in the sun and orientated to receive maximum solar radiation to heat the water contents of the pots. The orientation was adjusted after every 15 minutes. The data recording was continued until the water temperature exceeded 96 ^{o}C. .The average ambient temperature and the average solar radiation intensity over the time correspond. we used four thermocouple namely as type-1,type-2,type-3 and type-4 for better understanding of during calibration process. In calibration process for finding calibration factor, we take hypsometer and plate heater for heating of hypsometer and also used DPM. Solar radiation also measured by DPM so there calibration factor 1mV = 122.7 W/M^2 . By the calibration we found that Calibration factors these are show temperature reading equal to 1 mV in table 1.1:

TABLE: 3.1 CALIBRATION FACTOER OF THERMOCOUPLE

S.NO	Name of	Used placed	Value in Temperature
1	TYPE-1	Upper glazing	20.76
2	TYPE-2	Lower glazing	20.89
3	TYPE-3	Absorber plate	21.07
4	TYPE-4	Water in pots	21.12

4. Mathematical formulation:

4.4.1. First and second figure of merit:

There are two thermal performance parameters called figures of merit (F1 and F2) associated with testing box-type solar cookers as per BIS. The First Figure of Merit, F1, is determined from a stagnation test under no-load condition while the Second Figure of Merit, F2, is determined from test under full-load condition, taking water as the load

4.4.1.1. First figure of merit (F1):

The First Figure of Merit, F1. It is mathematically defined as:

$$F_1 = \frac{(T_{ps} - T_{as})}{H_s} \quad \text{---------- (1)}$$

Where T_{ps} is the plate stagnation temperature (˚C), T_{as} is the ambient temperature at stagnation (˚C), and Hs is the solar radiation intensity at stagnation (W/m^2)[17]

4.4.1.2. Second figure of merit (F2):

The Second Figure of Merit, F2, takes into account the heat exchange efficiency of cookers and is obtained through the sensible heating of specified load of water. F2 is evaluated through the following expression [17]

$$F_2 = F'\eta_o C_R = \frac{F_1 (MC)_w}{A\tau} \ln \left[\frac{1 - \frac{1}{F_1}\left(\frac{T_{w1} - \bar{T}_a}{\bar{H}}\right)}{1 - \frac{1}{F_1}\left(\frac{T_{w2} - \bar{T}_a}{\bar{H}}\right)} \right] \quad \text{---------- (2)}$$

4.4.2. Cooking Power of solar cookers:

In order to compare the different types of solar cookers, characteristic values need to be defined. These values are expressions of power. The average heating-power of a solar cooker is calculated as [10]

$$P = \frac{m_w \, X \, c_p X \, \Delta T}{\Delta t} \quad \text{---------- (3)}$$

where

m_w is the mass of water in kg, is the specific heat capacity at constant pressure

in 4186 J/(kg K), ΔT is the temperature difference in K, Δt is the duration of the measurement in s. Usually this power is measured from ambient temperature up to 96 ^{0}C, to avoid uncertainty of the exact boiling-point

4. Results and discussion:

5.1. Results of First figure of merit:

The stagnation test was conducted at Jabalpur engineering college Jabalpur (M.P.) India. On 15 /4/ 2014. The test started at 10.55 a.m. till the maximum absorber plate temperature was reached after 2 hours 15 minutes. The summary of the result of the test is given in Table 5.1.

Table5.1. Observation table for find out of F1 merit on dated 15/4/14

S.NO.	Local time (hh:mm)	Ambient Temperature (˚C)	Plate Temperature (˚c)	Solar Radiation (W/m2)
1	10:55	31	31	650
2	11:00	32	48	730
3	11:05	33	55	750
4	11:10	33	60	780
5	11:15	34	68	800
6	11:20	34	75	810
7	11:25	34	80	810
8	11:30	34	87	820
9	11:35	34	95	830
10	11:40	34	98	830
11	11:45	34	101	840
12	11:50	35	105	860
13	11:55	35	110	865
14	12:00	36	112	865
15	12:05	36	115	870
16	12:10	36	118	900
17	12:15	36	121	900
18	12:20	36	123	890
19	12:25	36	125	880
20	12:30	36	127	900
21	12:35	36	130	900
22	12:40	36	133	890
23	12:45	36	135	890
24	12:50	36	137	890
25	12:55	36	139	890
26	01:00	36	141	890
27	01:05	36	143	890
28	01:10	36	145	890
29	01:15	36	145	910
30	01:20	36	145	910

The stagnation plate temperature attained was 145 ˚C. The corresponding ambient temperature and solar radiation were 36 ˚C and 910 W/m2 respectively. F1 was calculated as per Eq. (1) and was found to be 0.120. This figure qualifies the box type solar cooker without finned absorber plate and reflector as Grade-A cooker, in accord with the criteria set by BIS

5.2 Results of second figure of merit:

Table5.2 Observation table for find out F2 merit on dated 17/04/14

S.NO.	Local Time (Hr: min)	Ambient Temperature (˚C)	Water Temperature (˚C)	Solar Radiation (W/m2)
1	10:45	31	31	750
2	10:50	31	33	780
3	10:55	32	36	800
4	11:00	32	36	850
5	11:05	32	37	860
6	11:10	32	38	740
7	11:15	32	39	760
8	11:20	33	40	770
9	11:25	33	42	790
10	11:30	33	44	750
11	11:35	33	49	820
12	11:40	33	50	835
13	11:45	33	52	845
14	11:50	34	55	855
15	11:55	34	58	870
16	12:00	34	59	870
17	12:03	34	60	890
18	12:05	34	62	880
19	12:10	34	65	880
20	12:15	34	68	885
21	12:20	34	70	900
22	12:25	34	72	925
23	12:30	34	74	925
24	12:35	35	76	930
25	12:40	35	79	940
26	12:45	35	80	940
27	12:50	35	82	950
28	12:55	35	84	940
29	01:00	35	85	950
30	01:05	35	86	950
31	01:10	35	88	940
32	01:15	35	90	900
33	01:20	35	91	830
34	01:25	36	93	890
35	01:30	36	95	850
36	01:35	36	95	840
37	01:40	36	96	830

The full-load test was conducted on 17/ 4 / 2014. The test started at 10.45 a.m. and was completed after 2 hours 55 minutes, when the temperature of the water exceeded 95 ˚C. The result of the test is given in Table 3. The result shows that it took 72 minutes to raise the temperature of the water from 60 ˚C to 90 ˚C. The average ambient temperature Ta and the average solar radiation H for the 72-minute period were found to be 34.5 ˚C and 914.1 W/m^2 respectively. F2 was calculated as per Eq. (2) and was found to be 0.485, a figure above the minimum value of 0.4 set by BIS for proper assessment of solar box cookers

5.3 Cooking power test:

This Experimental test was conducted at Jabalpur engineering college Jabalpur (M.P.) India. This experiment is performed on a simple type solar cooker without reflector. The test started dated on 18 and 19 /4/ 2014 with at 9:30 a.m. till the boiling temperature of water in pots is 96˚C. The summary of the result of the test is given in Table 5.3and table 5.4.

Table5.3: Observation table for Temperature at various point of cooker for heating test on dated 18/4/14

S.NO.	Local Time (HH:MM)	Solar radiation (W/m^2)	Upper glass of glazing tem.(˚C)	Lower glass of glazing tem.(˚C)	Plate temperature (˚C)	Water temperature in pots (˚C)	Ambient Temperature (˚C)	Wind speed (m/s)
1	09:30	553	37	55	57	27	27	0.23
2	09:45	640	39	70	70	30	27	0.26
3	10:00	670	42	76	78	39	28	0.27
4	10:15	710	47	88	90	44	28	0.25
5	10:30	690	45	83	92	55	28	0.30
6	10:45	740	48	87	95	62	31	0.15
7	11:00	770	51	89	97	66	32	0.29
8	11:15	750	49	88	102	69	31	0.21
9	11:30	820	52	93	110	74	34	0.22
10	11:45	860	53	95	115	82	34	0.28
11	12:00	870	54	98	122	88	34	0.19
12	12:05	877	54	99	123	90	34	0.21
13	12:10	884	54	102	124	91	34	0.23
14	12:15	890	55	103	126	91	35	0.25
15	12:20	895	55	103	126	92	35	0.26
16	12:25	905	55	104	127	93	35	0.24
17	12:30	910	55	105	128	93	35	0.26
18	12:35	912	55	106	129	94	35	0.24
19	12:40	913	55	107	130	94	35	0.23
20	12:45	915	55	108	130	95	35	0.30
21	12:50	921	56	109	131	95	36	0.16
22	12:55	928	56	109	132	95	36	0.21
23	01:00	934	56	110	132	96	36	0.19
24	01:05	937	57	111	133	96	37	0.14
25	01:10	940	57	112	134	96	37	0.20
26	01:15	946	57	112	134	96	37	0.24

Table 5.4: Observation table for Temperature at various point of cooker for heating test on Dated 19/4/2014

S.NO.	Local Time (HH:MM)	Solar radiation (W/m^2)	Upper glass of glazing tem.(^0C)	Lower glass of glazing tem.(^0C)	Plate temperature (^0C)	Water temperature in pots (^0C)	Ambient Temperature (^0C)	Wind speed (m/s)
1	09:30	542	31	42	54	29	29	0.28
2	09:45	560	31	43	56	34	29	0.26
3	10:00	574	32	44	58	37	30	0.28
4	10:15	586	33	45	60	42	30	0.24
5	10:30	596	33	46	63	46	31	0.29
6	10:45	615	34	47	66	50	32	0.23
7	11:00	633	35	48	67	52	33	0.26
8	11:15	660	37	54	70	57	34	0.16
9	11:30	680	39	60	79	64	34	0.18
10	11:45	698	40	63	83	69	35	0.23
11	12:00	722	43	70	89	76	35	0.24
12	12:05	732	45	75	95	79	35	0.26
13	12:10	748	46	80	104	82	36	0.27
14	12:15	760	47	85	110	84	36	0.28
15	12:20	780	49	88	114	87	36	0.26
16	12:25	800	50	91	117	89	36	0.25
17	12:30	820	52	94	120	91	37	0.24
18	12:35	846	53	96	123	93	37	0.23
19	12:40	870	54	97	127	94	37	0.19
20	12:45	898	55	99	129	95	37	0.26
21	12:50	918	57	102	130	95	37	0.21
22	12:55	926	58	104	132	95	37	012
23	01:00	939	60	106	133	96	37	0.19
24	01:05	948	61	107	134	96	38	0.20
25	01:10	952	61	109	135	96	38	0.21
26	01:15	969	62	110	136	96	38	0.20

The test started on dated 21,25and 27 /4/2014 at 9:30 a.m. till the boiling temperature of water in pots is 96°C. The summary of the result of the test is given in Table 5.5, Table 5.6 and Table 5.7. The boiling temperature attained was 96°C. All experimental data are given in tables;

Table 5.5: Observation table for Temperature at various point of cooker for heating test on Dated 21/4/2014

S.NO.	Local Time (HH:MM)	Solar radiation (W/m^2)	Upper glass of glazing tem.(^0C)	Lower glass of glazing tem.(^0C)	Plate temperature (^0C)	Water temperature in pots (^0C)	Ambient Temperature (^0C)	Wind speed (m/s)
1	09:30	557	35	46	60	27	27	0.5
2	09:45	591	37	52	66	34	28	0.23
3	10:00	624	39	57	73	40	29	0.28
4	10:15	660	41	62	79	44	29	0.24
5	10:30	699	44	68	85	51	30	0.30
6	10:45	735	48	71	92	58	30	0.27
7	11:00	771	50	75	98	63	31	0.29
8	11:15	805	55	79	105	70	31	0.23
9	11:30	839	59	85	113	78	32	0.21
10	11:45	873	63	92	121	87	33	0.16
11	12:00	890	67	99	129	93	34	0.18
12	12:05	892	67	100	132	94	34	0.015
13	12:10	895	68	101	135	95	35	0.20
14	12:15	899	68	102	137	95	35	0.29
15	12:20	899	69	103	140	96	35	0.24
16	12:25	900	70	104	142	96	36	0.27
17	12:30	902	71	105	143	96	36	0.29
18	12:35	903	72	106	144	96	36	0.30
19	12:40	905	73	107	146	96	37	0.31
20	12:45	906	75	109	147	96	37	0.32
21	12:50	908	77	110	149	96	37	0.26
22	12:55	909	78	112	150	96	37	0.24
23	01:00	912	80	114	152	96	38	0.21
24	01:05	914	81	117	155	96	38	0.16
25	01:10	916	83	119	157	96	38	0.18
26	01:15	917	85	121	159	96	38	0.23

Table 5.6: Observation table for Temperature at various point of cooker for heating test on Dated 25/4/2014

S.NO.	Local Time (HH:MM)	Solar radiation (W/m^2)	Upper glass of glazing tem.(^0C)	Lower glass of glazing tem.(^0C)	Plate temperature (^0C)	Water temperature in pots (^0C)	Ambient Temperature (^0C)	Wind speed (m/s)
1	09:30	585	40	56	67	31	31	0.25
2	09:45	606	42	58	70	35	31	0.23
3	10:00	635	45	61	74	40	32	0.26
4	10:15	660	47	63	76	45	32	0.29
5	10:30	700	51	66	79	50	33	0.30
6	10:45	740	55	70	84	55	33	0.21
7	11:00	770	58	76	90	66	34	0.19
8	11:15	800	64	88	98	73	35	0.18
9	11:30	825	67	90	105	79	35	0.11
10	11:45	855	71	95	110	86	36	0.21
11	12:00	870	75	100	117	91	37	0.19
12	12:05	879	76	103	120	93	37	0.25
13	12:10	888	76	105	123	94	37	0.29
14	12:15	892	77	107	127	94	37	0.32
15	12:20	896	79	114	132	95	37	0.15
16	12:25	902	81	118	135	96	38	0.09
17	12:30	906	82	121	138	96	38	0.11
18	12:35	908	82	121	140	96	38	0.12
19	12:40	911	83	123	141	96	39	0.23
20	12:45	914	83	123	143	96	39	0.24
21	12:50	916	84	125	143	96	39	016
22	12:55	919	84	126	144	96	39	0.18
23	01:00	922	85	128	145	96	40	0.26
24	01:05	924	86	129	146	96	40	0.23
25	01:10	926	86	130	148	96	40	019
26	01:15	928	87	130	150	96	40	0.26

Table 5.7: Observation table for Temperature at various point of cooker for heating Test on dated 27/4/2014

S.NO.	Local Time (HH:MM)	Solar radiation (W/m^2)	Upper glass of glazing tem.(^0C)	Lower glass of glazing tem.(^0C)	Plate temperature (^0C)	Water temperature in pots (^0C)	Ambient Temperature (^0C)	Wind speed (m/s)
1	09:30	573	38	50	64	29	29	0.34
2	09:45	600	40	53	68	34	30	0.25
3	10:00	630	42	55	70	38	31	0.29
4	10:15	680	45	69	75	47	31	0.24
5	10:30	720	47	73	80	55	32	0.16
6	10:45	770	50	77	83	64	33	0.19
7	11:00	800	54	86	92	70	33	0.24
8	11:15	825	56	90	98	74	34	0.13
9	11:30	850	58	95	110	80	35	0.28
10	11:45	870	61	98	119	86	35	0.30
11	12:00	900	62	103	126	93	36	0.28
12	12:05	902	62	104	130	94	36	0.16
13	12:10	905	62	106	134	94	36	0.21
14	12:15	910	63	107	136	95	36	0.31
15	12:20	912	63	109	138	96	37	0.28
16	12:25	913	64	109	139	96	37	0.21
17	12:30	913	64	110	140	96	38	0.30
18	12:35	914	65	110	141	96	38	0.25
19	12:40	916	65	111	143	96	38	0.29
20	12:45	917	66	111	144	96	39	0.12
21	12:50	918	66	112	145	96	39	0.16
22	12:55	920	67	112	147	96	39	0.18
23	01:00	922	67	114	148	96	39	0.25
24	01:05	924	68	114	149	96	40	0.22
25	01:10	925	68	116	151	96	40	0.27
26	01:15	927	68	116	151	96	40	0.19

From above calculation we construct a table and summarize results and select two days for find percentage of solar cooking power and reduce timing of solar cooking.

Table5.8: Results for heating test on various days

DATE	18/4/14 (old)	19/4/14 (old)	21/4/14(new)	25/4/14(new)	27/4/14 (new)
Mean ambient temperature(^{O}C)	33	36	34	36	36
Initial water temperature (^{O}C)	27	29	27	31	29
Time of water boiling in pots (min)	210	210	170	175	170
Mean solar radiation (W/m^2)	838	760	833	833	845
Temperature of boil water (^{O}C)	96	96	96	96	96
Cooking power (W)	119.20	115.74	147.24	134.74	142.98

And percentage increase of solar cooking power:

$$= \frac{(147.24-119.20)}{119.20} \times 100 = \mathbf{23.52\ \%}$$

And Time reduces for solar cooking:

$$= \frac{210-170}{210} \times 100 = \mathbf{19\ \%}$$

Now we saw that results, used without reflector solar cooker dated on 18 and 19 /4/ 2014 and find solar radiation 838 w/m^2 and 760w/m^2 respectively. Also we know that from result on 18/4/14 and 19/4/14 taking a time for the boiling temperature of both210 minute respectively. And another with used a two reflector type solar cooker with used finned absorber plate dated on 21/4/14, 25/4/14 and 27/4/14 and Find solar radiation 833 w/m^2, 833 w/m^2 and 845 w/m^2 respectively. Also taking a time for the boiling temperature 170 min,175 min and 170 minute respectively. So we discussed on 18/4/14 and 21/4/14. After modification of solar cooker we gated a minimum solar radiation on 21/4/14

Table5.9: Data analysis table of heating test of water 5.2 kg dated on 18/4/14

Mean ambient temperature (^{0}C)	33
Initial water temperature (^{0}C)	27
Time of boiling water in pots (Min)	210
Mean solar radiation (W/m^2)	838
Boiling temperature of water (^{0}C)	96
Heating power (W)	119.20

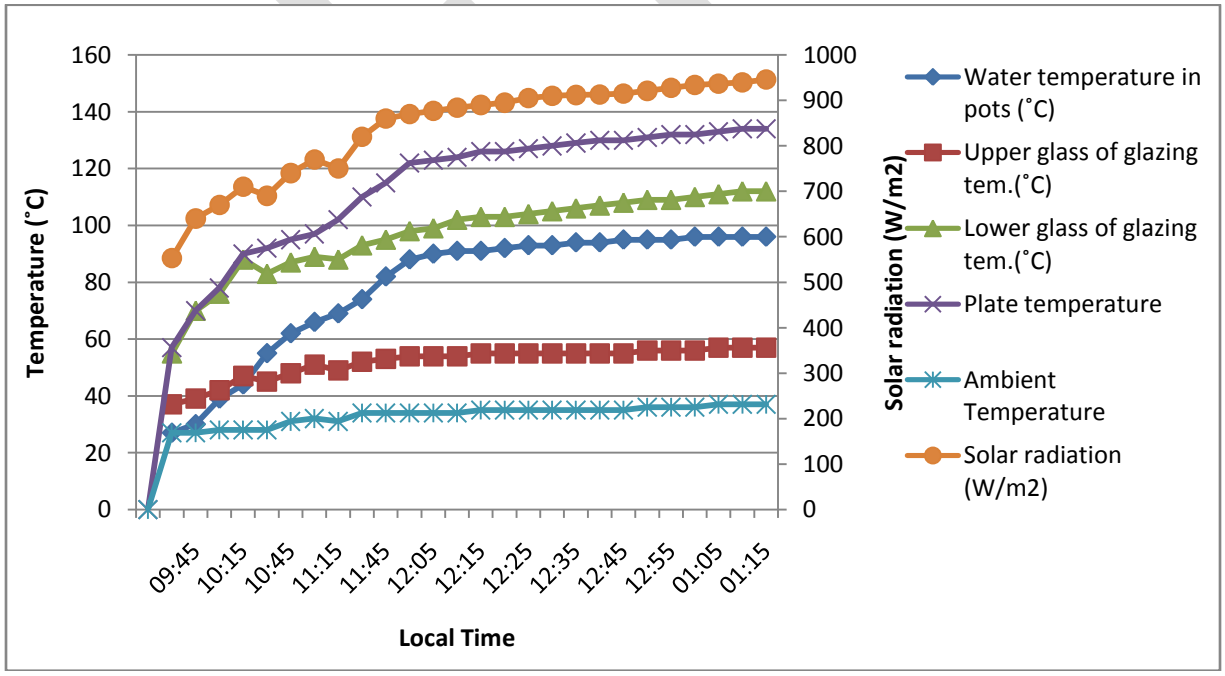

Fig 5.1 Graph between Temperature, Local time and Solar radiation dated on 18/4/14 (old Solar Cooker

Table5.10: Data analysis table of heating test of water 5.2 kg dated on 21/4/14

Mean ambient temperature (^{0}C)	34
Initial water temperature (^{0}C)	27
Time of boiling water in pots (Min)	170
Mean solar radiation (W/m^2)	833
Boiling temperature of water (^{0}C)	96
Heating power (W)	147.24

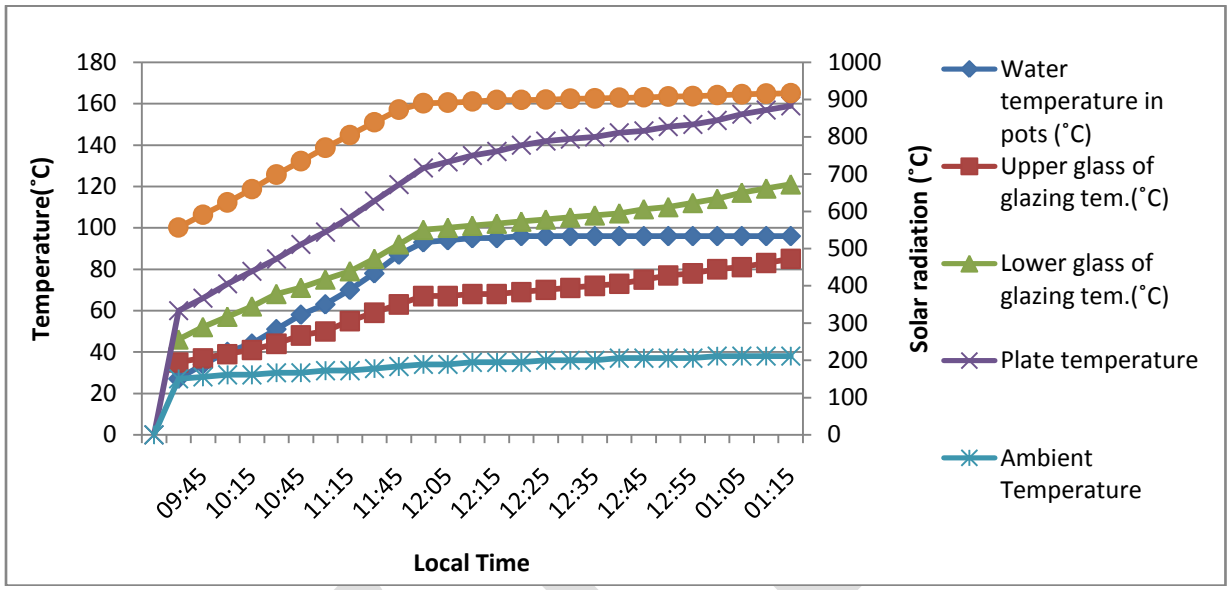

Fig5.2: Graph between Temperature, Local time and solar radiation dated on 21/4/14 (old Solar cooker)

I concluded these important results whose given information for our two reflector box type solar cooker employed with a finned absorber plate,

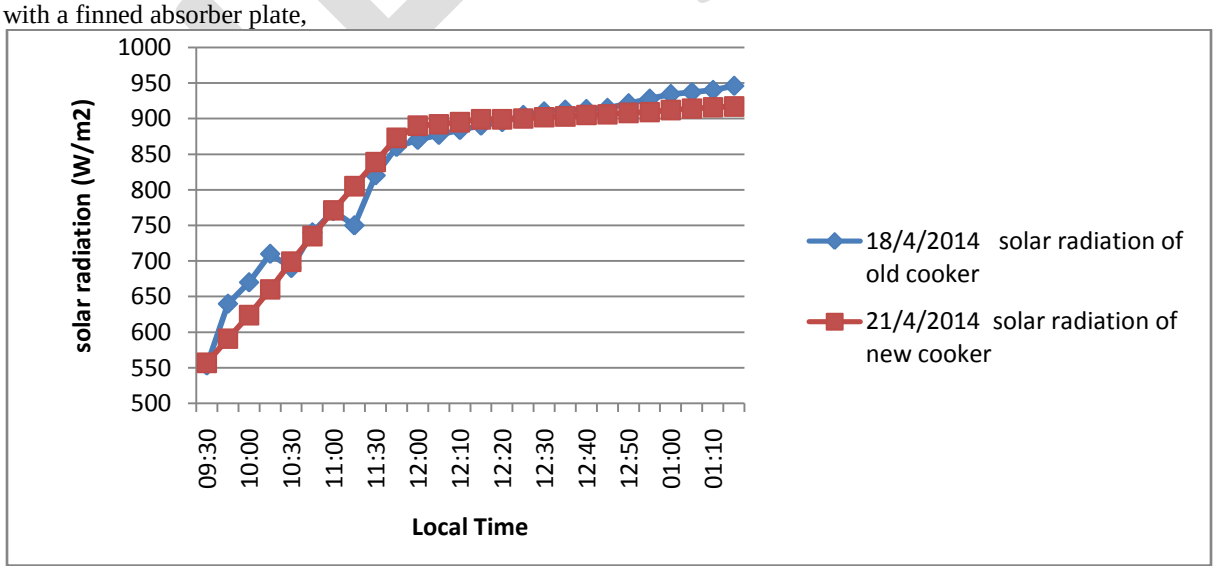

Fig 5.3.Graph Comparison between solar radiations dated on 18/4/14 and 21/4/14 with used simple Solar cooker and two reflector type solar cooker with finned absorber plate respectively

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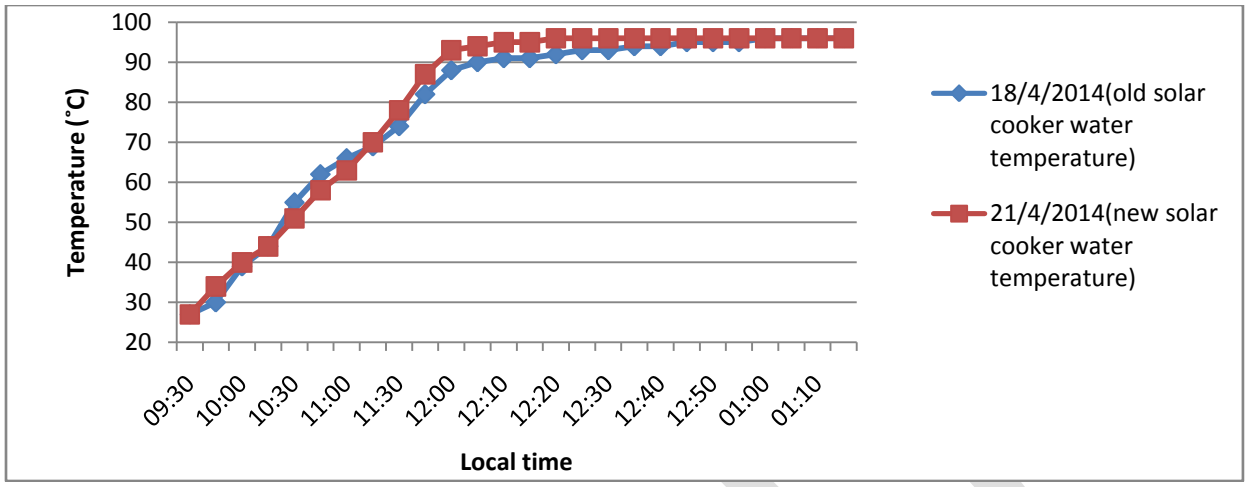

Fig 5.4: Graph comparison between water temperatures dated on 18/4/14 and 21/4/14 with used Simple solar cooker and two reflector type solar cooker with finned absorber plate Respective

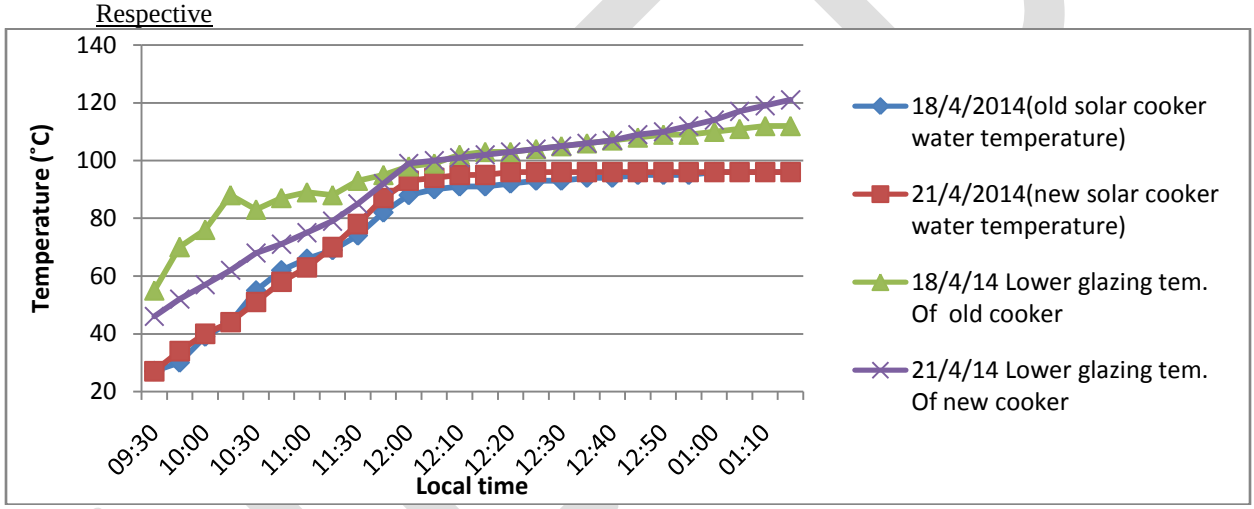

Fig5.5: Graph comparison between lower glazing and water temperature dated on 18/4/14 and 21/4/14 with used simple solar cooker and two reflector type solar cooker with finned Absorber plate respectively

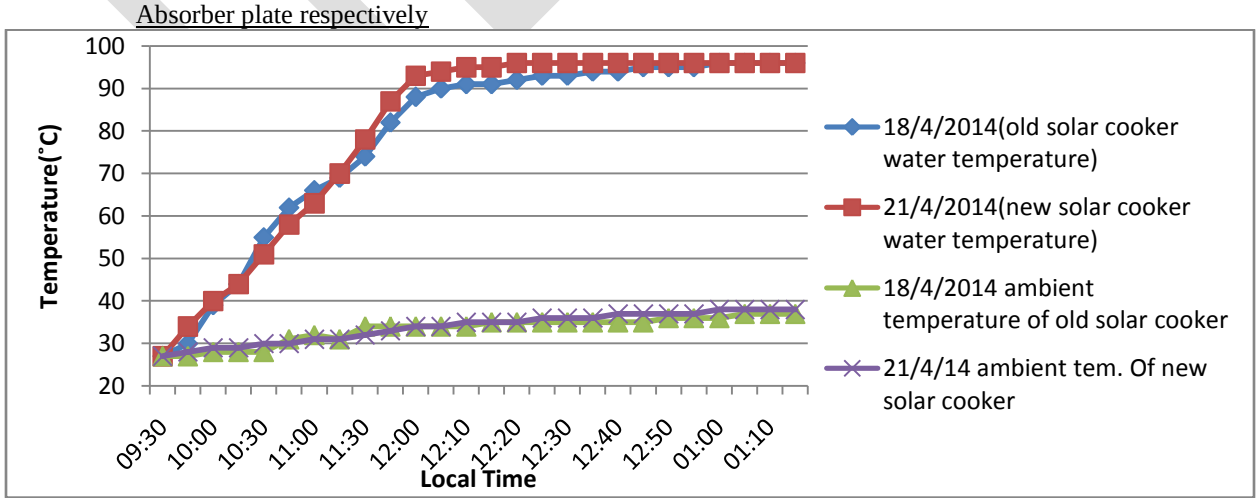

Fig 5.6: Graph comparison between ambient and water temperature dated on 18/4/14 and 21/4/14 With used simple solar cooker and two reflector type solar cooker with finned absorber plate Respectively

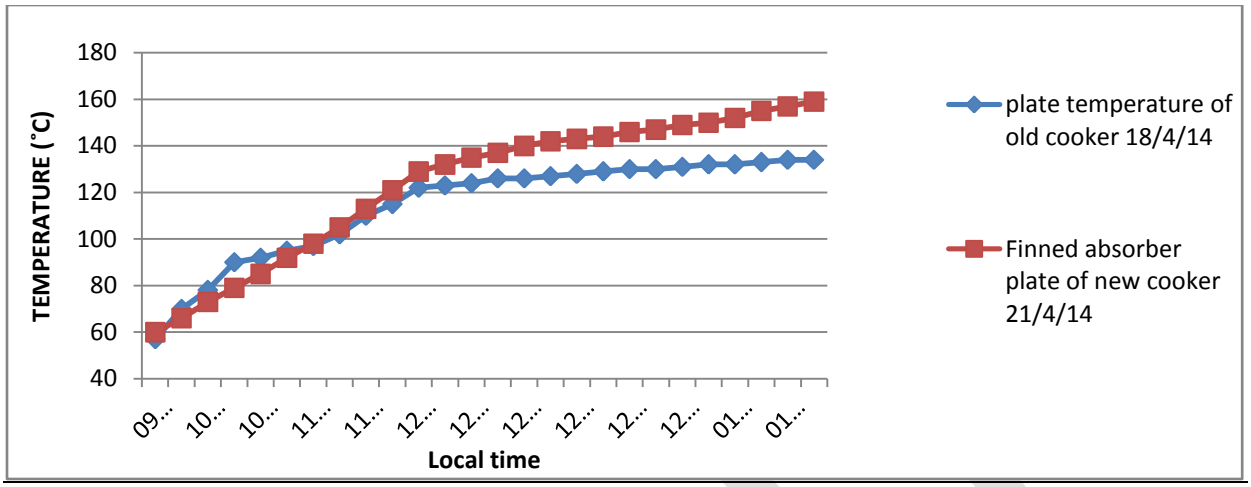

Fig.5.7: Graph comparison between simple plate and finned absorber plate temperature dated on 18/4/14 and 21/4/14 with used simple solar cooker and two reflector type solar cooker with Finned absorber plate respectively

5. CONCLUSION AND FUTURE SCOPE OF WORK

5.1 Conclusion:

1) The result of two tests revealed that5.2 kg of water was raised to 96 °C in 170 and 210 minutes for two reflector box type solar cooker with finned absorber plate and without reflector with simple absorber plate respectively and also average solar radiation available on 18/4/14 is 838 W/m^2 and on 21/4/14 is 833 W/m^2 for two reflector box type solar cooker with finned absorber plate and without reflector with simple absorber plate respectively.
2) The time reduced for boiling of water was 19% And cooking power was increased 23%.
3) The performance of the solar cooker has met the standard set by the Bureau of Indian Standards for box-type solar cookers.
4) The investigation has revealed that cooking time can be reduced by using a for two reflector box type solar cooker with finned absorber plate.
5) It has been clearly shown that the use of mirror boosters in solar box type cookers to get the additional sun energy. so time reduce for cooking and increase cooking power of box type solar cooker with used two reflector and finned absorber plate

5.2 Future scope of work:

1) Dimensions and geometry of the fins should be studied in more detail in order to optimize the performances of this kind of Solar cooker.
2) The investigation should be carried out at different season so as to understanding the Cooking profile of various periods in the year.
3) Studied the performance of two reflector box type solar cooker different- different angle of reflector mirror. Which angle has a suitable for gain a more and more heat for cooking purpose?

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