Performance Analysis of Autoclaved Aerated Concrete (AAC) Bricks box type Solar Cooker with Side Loading

Nilesh Deore[1], Prof. Priyanka Jhavar[2], Prof.Dr. Sanjeev Suryawanshi[3]

[1] *M Tech scholar, Mechanical Engineering Department, SSSUTMS-Sehore, Madhya Pradesh, India*
[2] *Professor, Mechanical Engineering Department, SSSUTMS-Sehore, Madhya Pradesh, India*
[3] *Professor, Mechanical Engineering Department, SSVPSBSD COE-Dhule, Maharashtra, India*

ABSTRACT

In many villages of our nation people are diverting towards LPG and gober gas for preparation of their food, still firewood is the basic fuel used for cooking purpose. There are several drawbacks of burning wood as fuel, such as it creates lot of smoke, clinkers, un-burnt carbon due to which carbon monoxide is liberated which is highly dangerous to living organisms this causes suffocation too. Also extensive cutting of trees, leading to deforestation increases pollution to large extent; depletion of ozone layer by increase in global warming is very harmful for environment. The main purpose of the present study is to develop low cost, eco-friendly solar cooker. Commercial solar cookers are costlier since made from high grade materials which a common man cannot afford. To overcome this problem an innovative low cost, eco-friendly autoclave aerated concrete (AAC) brick box type solar cooker with side loading arrangement is developed. It has been tested and parameters like efficiency, cooking power and figure of merits are evaluated.

Keyword: - *Box type solar cooker, Autoclaved aerated concrete (AAC), Side loading, Figure of merits, Thermal performance, Efficiency.*

1. INTRODUCTION

Solar energy is one of the forms of energy obtained by receiving heat and light from the Sun rays. It is renewable and green source of energy. This green source of energy is used for solar equipments. Technology has provided a number of ways to use this resource. Solar energy is available in large quantities and has been used as a source of heat. A 'solar cooker' is a device which uses the energy of direct sunlight to heat for cooking purpose. Lots of designs of solar cookers currently available in use are costlier. Commercial solar cookers are costlier since made from high grade materials which a common man cannot afford. To overcome this problem low cost eco-friendly autoclave aerated concrete (AAC) box type solar cooker is made for cooking purposes. This cooker help to the reduce fuel costs, air pollution, reduces the deforestation and desertification caused by get-together burning wood for cooking.

An autoclave aerated concrete (AAC) box type solar cooker is mainly a rectangular box with a top glass as a glazing; the heat losses over a larger surface area will partly offset the additional gain through having a greater heat collecting surface. The single reflector is used to increase the apparent collector area. This reflector can be made from a variety of materials and their main purpose is to reflect sunlight through the glazing into the cooking space inside of the box.

A box made of autoclave aerated concrete block which is an insulating material, with top face of the box fitted with a transparent glass medium. This enables the cooker to use incident solar radiation for cooking the food within the box. Mat black coated pot, preferably with selective coating is suggested for cooking.

Autoclaved aerated concrete (AAC) blocks are light weight, insulating and eco-friendly. These blocks consist of 80% air by volume. These blocks are made using Portland cement, quartz (silica), water and aeration agent. The mixture of these constituents is poured in mould. These blocks formed as a result of reaction of

Aluminium on a proportionate blend of lime, cement and fly ash, the hydrogen gas that escapes creates millions of tiny air cells give it a strong structure.

Due to these properties of AAC blocks (low density, good insulation, light in weight and easy to cut), it can be used to construct box type solar cooker. This solar cooker is made with low grade material such as AAC blocks and binding material. Glass, Aluminium sheet, black paint, and steel angle plates, black painted Aluminium pot. This solar cooker has side loading and innovative fixation of glass.

2. METHODOLOGY

In this study an AAC box type solar cooker is constructed of five AAC blocks, four AAC blocks having size 600X200X100mm and one having size 600X600X100mm, which are cut in required size by using cutting, machining and grinding tool. AAC box is formed by proper fixation of these blocks within the frame. Glazing is directly fixed in the slot made and this fixation of glass is innovative as compared to other solar cooker. Mirror of size 500X500mm is used which is not attached to solar cooker itself. The inside surface of box is painted by mat black colour. The aluminium cylindrical containers with mat black coating with lid having diameter 19.5cm in diameter and 10cm in height are used for cooking. Solar box cooker with single reflectors was designed, constructed and tested. The AAC box type solar cooker consists of an AAC rectangular blocks box, cooking unit, reflectors and a double glass cover.

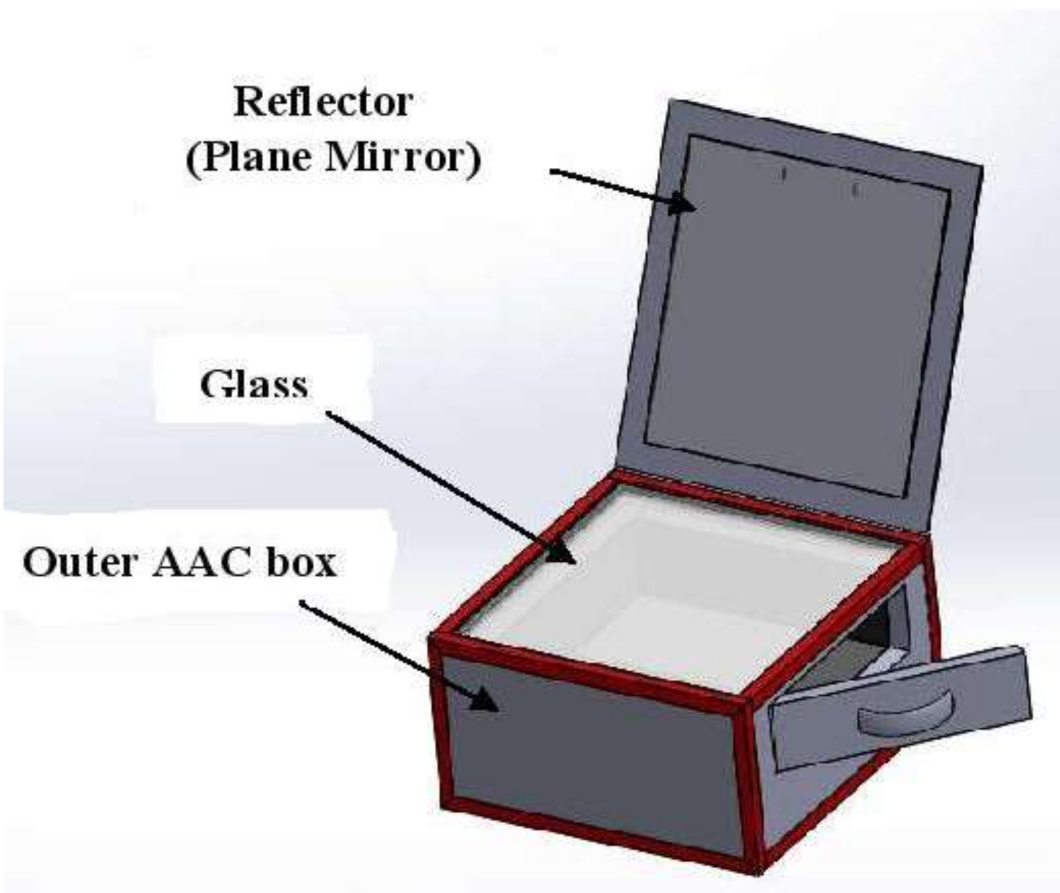

Fig -1(a): **AAC box type solar cooker with side loading.**

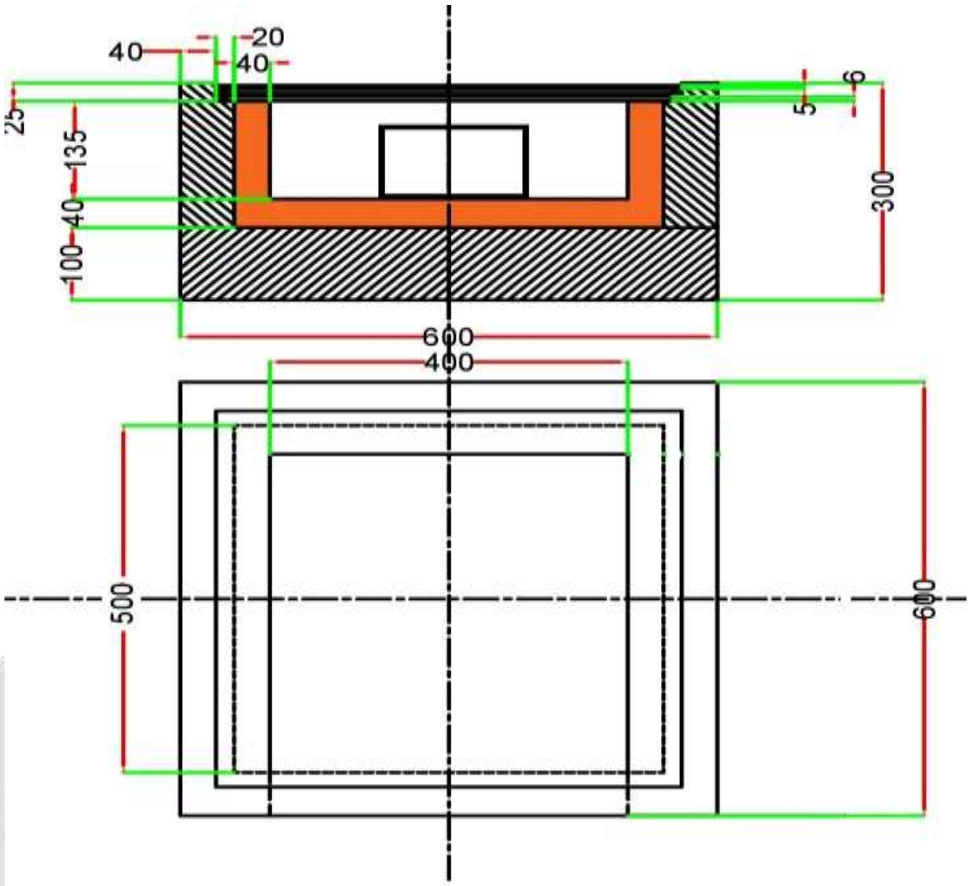

Fig -1(b): ***Sectional Front View and Top View of AAC Box type Solar Cooker*.**

3. SOLAR COOKER THERMAL PERFORMANCE

The Indian Standards Testing Method uses two figures of merit, calculated so as to be as independent of environmental conditions (such as wind speed, insolation, etc.) as possible.

1. Thermal Performance Test:-

The thermal performance evaluation of the solar box cooker involved estimation of the following parameters: First figure of merit (F_1), Second figure of merit (F_2) and Cooker efficiency (η_0).

1.1. Stagnation Temperature Test:-

To conduct this test the temperature measuring sensor with measuring device is required. The temperature sensor is fixed at the centre of the tray with proper thermal contact. This test is conducted on the clear day before 10am open the cooker to achieved stagnation temperature and record the final steady state temperature and the outside ambient air temperature and solar radiation at an interval of 10 min continuously.

1.1.2. First figure of merit (F_1)-

The First figure of merit (F_1) of a solar cooker is defined as the ratio of optical efficiency (η_o) the overall heat loss coefficient (U_L).

$$\therefore F_1 = \frac{\eta_o}{\mathrm{UL}}$$

Experimentally,

$$\therefore F1 = \left[\frac{T_P - T_a}{I}\right]$$

Where,

T_p = Absorber Plate Temperature (stagnation)

Ta= Temperature of Ambient Air.

I = Insolation on a Horizontal Surface (taken at time of stagnation)

1.2. Sensible Heating Water Test:-

This test is conducted to evaluate the second figure of merit. To conduct this test the temperature measuring sensor with measuring device is required. Fill cooking pots with water and calculate the exact mass of water. Place the pot in the cocking space and cover the reflector with black cloth. Insert the temperature sensor in the cooking pot to measure the water temperature inside the pot. Record the initial water temperature and final water temperature with corresponding time, average ambient air temperature and solar radiation and wind speed at an interval of 10 min continuously.

1.2.1. Second figure of merit (F2)-

The Second figure of merit (F_2) is evaluated under full load condition and can be expressed by the expression given as follows:

$$\therefore F2 = \left[\frac{F1\left(M_W C_{pw}\right)}{A \times t}\right] \ln\left[\frac{1 - \frac{1}{F_1}\left(\frac{T_{W1} - T_a}{I}\right)}{1 - \frac{1}{F_1}\left(\frac{T_{W2} - T_a}{I}\right)}\right]$$

Where,

I = Insolation on a Horizontal Surface (taken at time of stagnation)

M = Water Mass

Cp_w= Heat Capacity of Water

A = Aperture Area (the area of the lid)

t = Time in seconds.

T_a= Average Temperature of Ambient Air.

T_{W1} = Water Temperature at State 1 (initial)

T_{W2} = Water Temperature at State 2 (final)

2. Calculate Cooking Power:-

Cooking power is the ratio of change in temperature of water in each ten minute of interval multiplied by mass of water and specific heat of water contain in the cooking pot to the 600 seconds contained in ten minutes of interval.

$$\therefore P = \frac{(T_{W2} - T_{W1})MC_{PW}}{600}$$

Where,

P = Cooking Power (W)

T_{W1} = Temperature of the Water (initial)

T_{W2} = Temperature of the Water (final)

M = Mass of Water (kg)

Cp_w= Specific Heat Capacity of Water (4168 J/kgK).

3. Standardizing Cooking Power:-

Standardizing the cooking power will enables the comparison of results from different locations and dates. The average cooking power for each interval will be corrected to the set standard insolation of 700W/m^2.

$$\therefore Ps = P\left[\frac{700}{I}\right]$$

Where:

I = Average insolation (W/m^2)

P = Cooking power (W)

P_s = Standardized cooking power (P_s)

4. Temperature Difference:-

The ambient temperature of each interval is to be subtracted from the average cooking pot content temperature for each corresponding interval.

$$\therefore \boldsymbol{T_d = T_W - T_a}$$

Where,

T_d =Temperature difference (^{0}C)

$T_{W\,=}$Water temperature (^{0}C)

T_a =Ambient temperature (^{0}C)

4. RESULT AND DISCUSSION

The end result of stagnation temperature under no load condition is shown in Figure 2. The graph shows the variation in the insolation and ambient temperature and their effects on the stagnation temperature observed in the absorber plate of the solar cooker. The average ambient temperature for the test was 32.83°C. The maximum absorber plate temperature of 108°C was obtained after 2 hours 15 minutes. The plate temperature, ambient temperature and insolation versus time are plotted in Figure 2.

Table -1: Stagnation temperature test (F1) ON 08th September 2018

Sr. No.	Time	Tp	Ta	I	F1
1	11.45	85	30.4	658	0.083
2	11.55	87.4	31.3	677	0.083
3	12.05	89.8	32.3	689	0.083
4	12.15	92.5	32.6	697	0.086
5	12.25	94.1	32.7	701	0.088
6	12.35	98.2	33.4	716	0.091
7	12.45	99.8	34.2	708	0.093
8	12.55	104.5	34.6	703	0.099
9	1.05	106.4	33.8	782	0.093
10	1.15	108	33	676	0.111

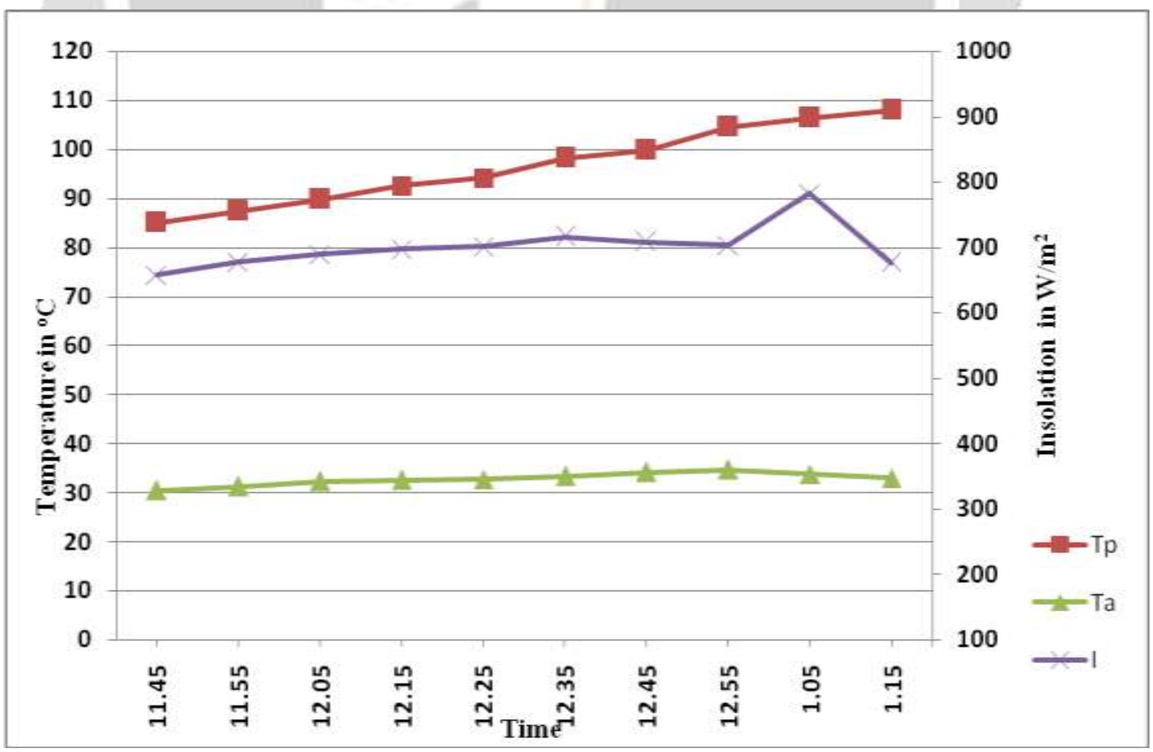

Chart -1: Variation of temperature with time

Table 2: Stagnation temperature test (F2) ON 10th September 2018

Sr. No.	Time	Tw	Ta	Td	I
1	11.05	32	30.4	1.6	658
2	11.15	37	30.6	6.4	677
3	1125	47	32.3	14.7	689
4	11.35	56.7	32.6	24.1	697
5	11.45	62.4	32.7	29.7	701
6	11.55	69.6	33.4	36.2	716
7	12.05	75.2	33.7	41.5	708
8	12.15	82.1	34.2	47.9	703
9	12.25	87.3	33.2	54.1	782
10	12.35	91.1	33.4	57.7	676
11	12.45	92.3	33.7	58.6	663
12	12.55	94.3	34	60.3	677
13	1.05	95.3	34.3	61	689
14	1.15	96	34.6	61.4	697

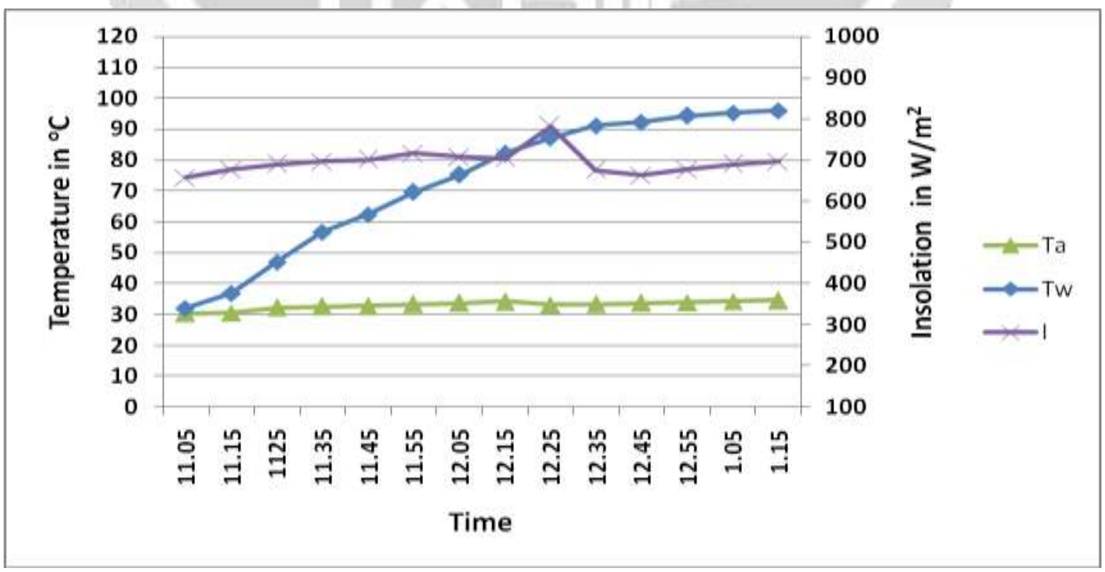

Chart -2: Variation of temperature with time

5. CONCLUSION

The AAC box type solar cooker found to be prominent option to commercial solar cookers made up from high grade materials. Thermal performance characteristics and parameter of this solar cooker are closer to standard values. The cost which is one of the hurdles in usage of box type solar cooker is reduced up to 40 percent compared to commercial solar cooker. This type of cooker uses low grade material for manufacturing, makes it eco friendly.

3. REFERENCES

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