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Estimating The Cooking Power And Figure Of Merit Of A Double Pot Solar Hot Box

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***Abstract*—A solar hot box was constructed for domestic water heating purpose in two pots of different colors. The work estimates the performances of a double pot solar hot box by determining its cooking power and comparing their figures of merit. The duo vessels were subjected to the same ambient conditions and solar irradiances during experimentation. At interval of 30minutes, the solar irradiances, ambient temperatures, pots and fluid temperatures were taken for six hours of the day. The resulting measured data were presented in a table and a graph. Mean values were used for computation of necessary cooking parameters .Computation shows that the black pot exhibited standardized cooking power of 449W and figure of merit of 0.04Km^{2}W^{-1},while the unpainted counterpart indicated standardized cooking power of 412W and figure of merit, 0.03Km^2 W^{-1} in each case.**

Keywords—Cooking power, Estimation, Figure of merit, Hot Box

I. INTRODUCTION

A solar cooker is designed to trap the Sun's energy in an insulted box. It is an attempt to convert the solar wastes to useful wealth as it will surely reduce the demand for local firewood and maintaining a cleaner environment. Sunlight, both direct and reflected enters the solar box through its glass cover; it turns to heat energy when it is absorbed by the black absorber plate and pot. The heat input caused the temperature inside of the solar box cooker to rise until easily achieved. The radiant energy from the pot from within the box now having longer wavelength cannot pass or back out through the glass cover and is trapped. The theoretical analyses of parameter for the hot box were completed the following mathematical relations:

1. Temperature difference

   $T_d = T_{w-} T_a$

2. Interval cooking power, pc$\frac{MC\,(T_{2-}T_1)}{650}$

3. Standardized Cooking Power, Ps = $\frac{700}{I_s}$

4. Figure of Merit, F$_1$ = $\frac{n}{u}$ = $\frac{T_{p-}T_a}{I_s}$

NOMENCLATURE

T_a = Ambient temperature

T_{f1} = Temperature of Fluid in unpainted pot

T_{f2} = Temperature of Fluid in black pot

I_s = Solar irradiance

T_{p1} = Temperature of unpainted pot

T_{p1} = Temperature of black pot

η_0 = Optical efficiency of the glass cover

C = Specific heat capacity

P = Cooking power

P_s = Standardized cooking power

T_d = Temperature difference

F_1 = Figure of merit

A = Aperture area of hot box

MATERIALS AND METHOD

Plate 1: Show the solar hot box having two plate of aluminum pots of same size but different colors namely, black and unpainted. The experimental set-up includes the solar meter, thermocouple, digital thermometer. The cooking vessels containing one litre of water were arranged beside each other inside the hot box. The hot box was placed to receive insolation of the sun from 9:00am to 1500p.m. In each instance, the ambient temperatures were taken with other relevant temperatures namely; the fluid temperatures, hot box inside temp and the pot temperatures Units

RESULTS AND DISCUSSION

The mean responses of each of the pot to solar irradiance at the difference time are presented in table 1 and figure 1. The result of the experiment was used to compare the following parameter for each of the pots:

i. Stagnation temperature test of the hot box for first figure of merit (F_1)

ii. Water heat up test of the hot box for second figure of merit (F_2); and

iii. Standardized Cooking Power.

Mean values of the experiment readings were used for computation, of figures of merit and cooking power.

Table 1: Temperature Variation in the Hot Box

t	I	TA	TP1	TF1	TP2	TF2
900	280	31	35	35	35	35
930	330	31	38	38	36	39
1000	380	34	42	45	40	48
1030	805	34	42	45	45	53
1100	240	33	42	44	45	55
1130	820	35	44	46	54	58
1200	860	36	48	50	67	70
1230	879	37	66	69	72	74
1300	935	37	70	73	76	80
1330	385	36	63	63	71	74
1400	758	37	64	66	71	78
1430	220	35	63	65	57	76
1500	140	36	59	60	59	70

SOURCE : AUTHORS FIELD WORK (2016)

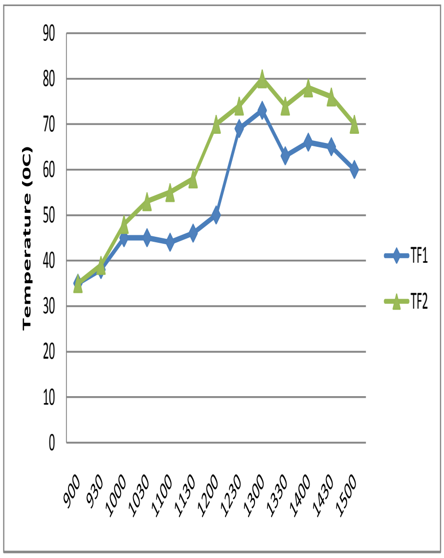

Fig. 1: Temperature Variation against Time of the Day

FIGURE OF MERIT

This is a numerical value representing a measure of effectiveness, efficiency, performance or other important factor and ascertained or approximated figure analysis, appraisal or estimation techniques.

FIGURES OF MERIT FOR THE UNPAINTED POT

1. Figure of Merit F_1

   $F_1 = \frac{7_0}{U} = \frac{T_p - T_a}{I}$

   Where T_p = 53, T_A = 35^0 and I = 533W/m^2

   :. $F_1 = \frac{53-35}{533} = 0.03\ Km^2\ W^{-1}$

2. Figures of Merit for the Black Pot

   Where T_p =56^0c, T_A = 35, I = 533

   $F_2 = \frac{56-35}{533} = 0.04Km^2\ W^{-1}$

Interval Cooking Power and standardized Cooking Power for the unpainted pot

3. Interval Cooking Power was computed as follows:

   $P = \frac{Mc\ \Delta T}{600}$

   $= \frac{1\ x\ 4{,}86\ (73-31}{600}$

   = 314W

4. Standardized Cooking Power

   $P_s = \frac{700P}{I_s} = \frac{700P}{533}$

   = 412W

Interval Cooking Power for the painted pot

5. $P = = \frac{Mc\ \Delta T}{650}$

   $= \frac{1\ x\ 4186\ (80-31}{600}$

   = 342W

6. The standardized Cooking Power for the painted pot

   $P_s \frac{700P}{I_s}$

   $= \frac{700\ x\ 342}{533}$ = 449W

CONCLUSION

The research was carried out to estimate the performances of a solar box. Results show that the block pot exhibited cooking power and figure of merit than the unpainted counterpart. The figures of merit and the cooking power were the determinant of the collector efficiency function in each case. Therefore the black pot is more preferred for solar healing application as it is 25% more efficient. That the unpainted when subjected to the some ambient condition and solar irradiance.

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