

Thermal Analysis of Selective Absorber Coatings Based on Smoke for Application in Spiral Concentrating Type Solar Cookers

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Abstract

The thermal properties of selective absorber coating of a spiral concentrating type solar cooker has been analysed. Coating has been prepared using smoke. Even though the common type of solar cookers have been used for thermal analysis, the concentrating type solar cooker showed a better result to obtain very high temperatures. Investigations have been done with smoke which is readily available in Villages and cost effective. Various thermal parameters such as standard cooking power and overall efficiency have been calculated in this Study. Aluminium vessels with smoke coating has been used in this study which has been compared with the performance of Aluminium absorbers, coated with lamp black and black primer paint. The cost effective, readily available smoke was found to be a better solar selective coating which is suitable for villagers.

Keywords: Spiral concentrator, selective surface, thermal parameters.

1. Introduction

In rural areas solar cooker is a viable and a promising device that uses solar radiation to cook food, which preserves the nutrition value. The common type of solar cookers are box type cooker, parabolic concentrator, umbrella type cooker, hybrid cooker, conical concentrator, Fresnal concentrator, spiral concentrator etc. With spiral concentrators we can obtain very high temperatures. Considering the

cost effectiveness, portability and simplicity, spiral concentrator is a suitable one for villagers.

Selective solar absorber coating is important in spiral concentrating type solar cooker, which converts solar radiation into heat energy. To get maximum photo thermal conversion, the selective absorber should have high absorptance and low emittance at operational temperature [1] Usually materials which are used for the fabrication of solar cooker are expensive. So for the people with low income, a low cost material for selective absorber must be identified. So a spiral cooker with stainless steel concentrator is fabricated with reduced constructing cost and locally available materials are used. [4,5,6]. The readily available material called smoke particles in rural areas has been used as a selective coating for absorber for spiral concentrating type solar cooker. The absorber with smoke coating is made to get exposed in direct sunlight under various weather changes for several hours.

2. Thermal Parameters

To compare different cookers thermal parameters are used [2]. The standard cooking power P_s and overall efficiency η_f are calculated using the formula.

$$P_s = P_c \frac{700w}{\frac{m^2}{I}}$$

P_c is cooking power and I is the insolation (w/m^2)

$$P_c = mc_p = \frac{dT}{dt}$$

m is the mass of water, C_p in the sp. heat capacity of water and T is the temperature of water at time t .

The overall efficiency [3] is calculated as

$$\int \frac{mC_p(T_{wf} - T_{wi})}{A(\Delta t)}$$

where T_{wf} and T_{wi} is the final and initial temperature and A is the area of the concentrator.

3. Experimental

3.1. Preparation of the material coating

Smoke particles have been used as the coating for selective absorber and aluminium pot was selected. Smoke is applied uniformly over the outer surfaces of the pot by exposing them to the smoke from a candle or kerosene lamp. To compare the performance of smoke coating other pot painted with commercially available black primer paint and lamp black were used. The spiral concentrator with absorber is shown in Fig 1.



Figure 1. Concentrator with Absorber coated with smoke

3.2. Thermal parameter Measurement

3.2.1. Water heating test

In order to carryout the water heating tests, three Al vessels coated with smoke, lamp black and black primer paint were used. To start with, the stand is directed towards the sun to set azimuth. The absorbers were loaded with 0.964 kg of water. The concentrator is adjusted until the absorber is in the region of brightest illumination. Insolation temp of water and ambient temp. Were noted down at an interval of every 2 minutes. N.I precision, pyrliometer was used for measuring solar insolation and temp of

water was measured by digital thermometer. (portable)

Table 1. Water heating test for smoke, lamp black and black primer

Date : 30.05.17

Absorber material : Aluminum

Starting time : 12.41pm

Amount of water : 0.964kg

Ambient temp. : 29.5°C

Time Minutes	Insolation W.m ²	Temp of absorber coated with		
		Smoke °C	Lamp Black °C	Primer Paint °C
0	617	29	29	29
2	631	36	35.8	35.5
4	624	44.6	44.1	44
6	635	54.1	53.7	53.5
8	624	59.8	59.4	59
10	632	67	66.5	66.4
12	664	73.1	72.5	72.2
14	667	78.9	78.2	78.1
16	662	84.8	84.2	84.1
18	667	89.4	89.1	84.9
20	662.8	92.8	92.14	95.01
24	667	98	97.5	97.2
25	667	100	98	97.9

4. Result

By knowing the thermal parameters the coating performance was analyzed three absorbers were used to test the investigated coating. The overall efficiency was determined. The following table shows the effectiveness of the selective coating.

Table 2. Summary of thermal parameters

Coating Parameters	Smoke	Lamp black	Primer paint
Ps (Watts)	78	72	59
(%) η	82	76	20.5

5. Conclusion

The thermal efficiency and cooking power of smoke as a selective solar coating has been investigated. This coating depicts better results than other commercially available lamp black & primer paint coatings. The cheap material smoke could be



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used as the selective solar coating for spiral concentrator

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