IMPACT OF REFLECTIVE MATERIAL ON SOLAR COOKER PERFORMANCE

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Abstract

Three similar panel solar cookers with different reflective material were tested and evaluated in order to find out the impact of reflective material to the thermal performance of the cooker. The results have been evaluated according to international standard method for solar cookers performance evaluation and the difference in thermal performance among the three cookers has been proven statistically insignificant at a 5% level of significance.

Key words: panel solar cooker, CooKit, reflective material, standardized cooking power

INTRODUCTION

Solar cookers are nowadays of a growing importance worldwide. It is basically a device which uses the energy of solar radiation for cooking or boiling of water (Solar Cooking Archiv). There are three basic types of solar cookers but this study only refers to panel-type cookers.

The CooKit is a solar cooker of the panel type which has been in use in many countries in the tropical and subtropical region. So far there have been more than 500 000 CooKits manufactured and distributed all around the world. The construction of the cooker is very simple and does not require a lot of components but still the original material can be unavailable in a certain regions and need to be replaced by available ones.

This article reports on a study on the impact of different reflective material on the CooKit solar cooker thermal performance.

MATERIALS AND METHODS

Three solar cookers have been manufactured according to the original CooKit manufacturing instruction (Schwarzer ang Da Silva, 2008). All the cookers have the same dimensions and an identical recycled cardboard frame as the original model. The only difference is in reflective material and its bonding to the cooker frame.

The first cooker was manufactured of standard kitchen tinfoil and common office glue stick (material cost 2€ for a cooker) exactly as recommended in the instruction manual (Schwarzer and Da Silva, 2008), the second cooker was made of self-adhesive mirror-like wallpaper (material cost 10€ for a cooker) and the third cooker of the inner foil of cigarette boxes (various brands) bonded to the frame with wheat paste. Wheat paste is self-made glue made of 1 spoon of wheat flour cooked shortly with 200 ml of water. For this cooker there was virtually no material cost at all.

All the three cookers have been tested simultaneously to avoid the undesirable influence of external conditions. The similar black painted aluminum vessels filled with 1 liter of water of ambient temperature have been used for all the tests. The cooking vessel was always put in a baking oven bag to decrease the heat losses during the test. The temperature measurements have been taken with immersion thermocouples connected to a datalogger and meteorological data such as ambient temperature and solar irradiation were taken form a nearby weather station.

The performance of the cookers has been measured and calculated according to the ASAE S580 standard (Funk, 2000; ASAE, 2003) and was reported as a Standardized Cooking Power at a temperature difference of 50°C. The Standardized Cooking Power (SCP) was calculated according to this formula:

$$SCP = \frac{\left(T_{w2} - T_{w1}\right)}{\Delta t} m_w c_{pw} \frac{I_n}{I_a}$$

SCP = standard cooking power (W)
T_{w1} = initial water temperature (°C)
T_{w2} = final water temperature (°C)
m_w = mass of water (kg)
c_{pw} = heat capacity of water ($J.kg^{-1}.K^{-1}$)

Δt = normative interval (600 s)
I_a = average horizontal insolation ($W.m^{-2}$)
I_n = normative insolation (700 $W.m^{-2}$)

All the tests have been performed in Prague, Czech Republic during June–August 2009 at the Czech University of Life Sciences in Prague.

RESULTS

There were 10 tests performed simultaneously with all the three cookers and the results were then statistically evaluated. During the testing period all the cookers have reached almost the same Standardized Cooking Power varying generally between 30 and 35 W (Figure 1).

The difference among the three cookers performance has been proven statistically insignificant at a 5% level of significance.

The time necessary to increase the water temperature for 50°C varied between 112 and 157 minutes depending mostly on the intensity of solar radiation during the test (Figure 2).

Generally the cooker with self adhesive reflective foil reached the best thermal performance however the difference was quite small and not statistically significant.

Although all the cookers have almost the same thermal performance, there was a significant difference in time demand for manufacturing the cookers. By far the most time demanding was the cigarette cooker (about 10 hours) followed by the tinfoil and wallpaper cooker (about 1.5 and 1 hour respectively).

CONCLUSION

The panel cookers reach generally lower thermal performance than the other two solar cooker types but this performance is mostly based on the cooker type itself not on the reflective material used during construction. All the three cookers reached almost similar values of thermal power. The cigarette-box solar cooker will certainly not replace the classical tinfoil CooKit at a large scale but it can be successfully used in conditions where modern material is unavailable or scarce.

Figure 1: Average Standardized Cooking Power

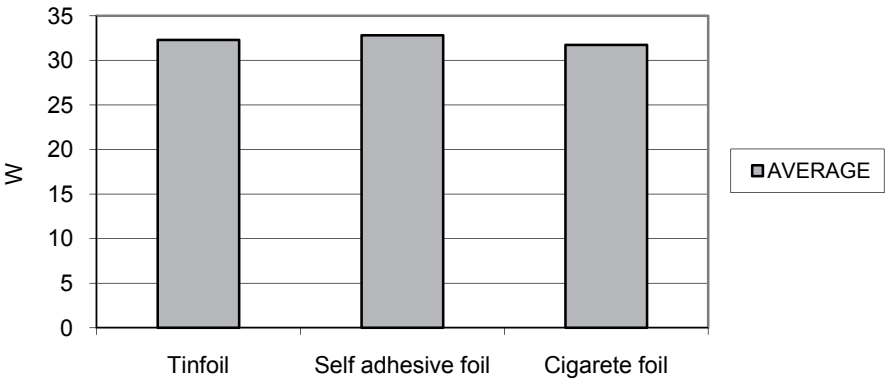

Figure 2: Water temperature rise during cookers testing (14. 8. 2009)

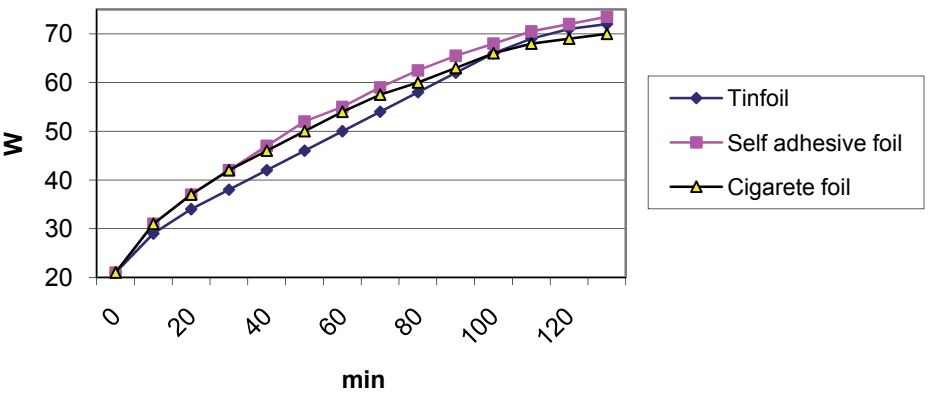

Figure 3: Testing of the cookers (Prague 4) – August 2009

Figure 4: Testing of the cookers (CULS Prague campus) – July 2007

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