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DEVELOPMENT AND VALIDIFICATION OF TEST STANDARDS FOR CONCENTRATING SOLAR COOKERS

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Abstract—The most common type of energy used is firewood. In some Sub Saharan countries, up to 90% of total energy use is from firewood. It also led to environmental degradation due to deforestation and scarcity of firewood. Solar energy is a non-consumptive and non-polluting fuel. It is a 8 penal parabolic shape solar concentrator cooker. The material used for the penal is anodizing aluminum sheet. This paper presents the results of the study of the efficiency, performance, optimum size/capacity, types of materials to be used optimal design, affordable cost and various testing result of the concentrating solar cooker. Also the temperature getting in various environment and the effect of wind. It has also include the food prepare for how many people and in how much time and measure the performance of concentrating solar cooker in various condition and development for various issue are facing in cooking of food.

Keywords- Solar, Concentrator, Parabolic, Cooker, Material, Optimum.

I. INTRODUCTION

The use of solar energy to cook food presents a viable alternative to the use of fuel wood, kerosene, and other fuels traditionally used in developing countries for the purpose of preparing food. It help to prevent deforestation because in rural area preparing the food wood is used and for this Women in rural areas are forced to walk long distances up to 7 km or more with heavy burdens of wood fuel. While certainly, solar cookers cannot entirely halt the use of combustible fuels for food preparation, it can be shown that properly applied, solar cooking can be used as an effective mitigation tool with regards to global climate change, deforestation, and economic debasement of the world's poorest people. Solar cooking presents an alternative energy source for cooking. It is a simple, safe and convenient way to cook food without consuming fuels, heating up the kitchen and polluting the environment.

It is a 4 seq. meter area solar penal which is made of anodize aluminum sheet which collect 700 to 750 watt per seq. meter intensity of solar light. It manufactured in eight panel because to protect from wind and other damage and also for easy transportation. The reflectivity of parabolic dish is approximately 86%. For proper focusing of solar light on pot two adjustment is given one is the wheel of the setup which is used to move the setup for direct sunlight on dish and other is the movement of penal for exact focusing of light on the pot so we get the higher temperature up to 400 degree Celsius. In this we perform two test on solar concentrator panel of "prince 40" the first one is "optical efficiency test" and the second one is "performance test".

II. TEST PROCEDURE

We conducted two type of test first is optical efficiency test and second is thermal efficiency test. Which are defined for evaluating the performance of solar concentrator dish. The optical efficiency factor gives the theoretical upper limit of the overall efficiency of concentrator.

2.1 Optical efficiency test-

Optical efficiency is defined as the component of solar radiation that reaches the receiver. This is a function of reflectivity of the reflector surface, absorptivity of the receiver and intercept factor. Intercept factor means how much of the reflected radiation reaches the pot. There will be some part of radiation that will not reach the pot. Use a black aluminum pot of suitable size (as Procedure to carryout optical efficiency test:

A. Recommended by the manufacturer). If outside of the pot is not black enough paint it with blackboard paint. Put thin layer of paint and not thick layer. Thick layer is a barrier to heat transfer. If already applied paint is there and you want to repaint the pot then remove the same with polish paper before applying new paint. If manufacturer has provided any standard pot then use the same. Take weight of the pot say (M_p) in kgs.

B. Fill minimum 15 liters of water in aluminum pot or cooker. Check that the temperature of water is at least 5 degree less than ambient temperature. If not one may mix some ice to lower this temperature.

C. Weigh the pot and the water together. Mass of water (M_w) is combined mass minus mass of pot. Keep this pot on the focus, adjust the focus and record time. Record water temperature at start (T_{Wi}) and ambient temperature (T_a).

D. Continuously record water temperature. Slowly stir water in between without spilling it. Stop taking readings once the water temperature reaches near about 10 degrees above ambient temperature. Defocus the solar concentrator. Record the time. Record the final temperature (T_{wf}).

E. Also record direct radiation(I_d) and diffuse radiation (I_{df}). Direct radiation is to be recorded when pyranometer is facing the Sun and diffused radiation is to be recorded by blocking the sun from the distance.

Caution:-Throughout the test also record wind velocity with anemometer. If wind velocity exceeds 3 m/sec for more than 2 minutes, discard the test and take a fresh test.

2.1.1 Calculations-

Calculate instantaneous normal beam radiation

Ibn as = direct radiation (I_d) – diffuse radiation (I_{df})

Calculate average value of Ibn over test period.

Input energy = Average Ibn (Watt/sq-m)*Aperture area*time in seconds/1000 in KJ.

Energy Gain = M_P*C_{PP}*($T_{wf} - T_{wi}$) + M_w*4.187*($T_{wf} - T_{wi}$) KJ

Cpp is specific heat of pot material.

Optical efficiency = Energy gain*100/Input energy in %.

2.2 Performance test-

A. Take 2 litres of water per sq. of area. For PRINCE-40 solar cooker take approximately 8.5 litres of water to start.

B. Take initial total weight of the pot with water,(M_o).

C. Use open pot. Keep the pot on the solar cooker without lid and focus. Start the test.

D. Keep the weighing machine very close to the solar cooker.

E. Take continuous readings for total direct radiation, diffuse radiation, wind velocity and water temperature against time.

F. At some point the water temperature will reach near stagnation (most probably above 90° C). This is boiling point. Record boiling temperature T_{Boil}. At this time take the pot down on the weighing machine, record combined mass of water plus pot as M_i, and put the pot back on the solar cooker and focus it. This action of removing the pot from the solar cooker, weighing it and again putting back on solar cooker should be done carefully but in shortest possible time to have minimum temperature drop of the water. Record water temperature. Record start time.
G. Wait for one hour; track the solar cooker every 10 minutes. At the end of one hour defocus the dish. Wait for 5 minutes and then remove the pot and weigh it on the weighing machine to get final weight M_f.

2.2.1 Calculations-
Mass of water lost in one hour = $M_{wl} = M_f - M_i$.

Heat gain during one hour = $M_{wl} * h_{fg}$ (2260 kJ).

Input energy =Average Ibn (Watt/sq-m)*Aperture area*time in sec/1000 in KJ.

Thermal efficiency measured in field condition = Heat gain*100/Input energy in %

Energy reaching the pot = Input energy * optical efficiency in kJ.

Losses from the pot in field condition = Energy reaching the pot – Heat gain

Normalized losses to boiling temp.100 degree and ambient temp of 25 degree.
= Losses from the pot in field condition * (100-25) / ($T_{Boil} - T_a$)
(T_a) should be average of ambient temperature over test period of one hour)

Normalized input energy at 750 Watt/sq-m = input energy in field condition*750/Average lbn
(Can also be calculated as 750 Watt/sq-m* A_a * 3600 sec /1000 kJ).

Normalized heat gain = normalized input energy – normalized losses.

Normalized single point efficiency = normalized heat gain*100/normalized input energy.

Reporting single point normalized efficiency accommodating variables like lbn and Delta T is the innovative approach adopted in this development of test protocol.

III. OBSERVATIONS

Measurements were recorded using data logger for stagnation temperature, ambient temperature, solar radiations and water temperatures. For heat duty measurement, temperature of water was kept below 90°C to avoid error that can creep in because of evaporation of water.

3.1 Observation table –

3.1.1 Thermal efficiency test-

Sr. No.	Time (in sec.)	Tem. Of water	Amb. Temp.	Direct radiation	Diffuse radiation	lbn
1	0	27	31.5	820	110	710
2	300	32	31.5	810	90	720
3	600	36.5	32	840	110	730
4	900	41	32	825	105	720
5	1200	45	32	840	110	730
			31.5	827	105	722

3.1.2 Thermal performance test-

Sr. No.	Time	Water temp.	Amb. Temp.	Direct beam radiation	Diffuse beam radiation	lbn	Wt. of pot with water
1	11	30	32	850	150	700	13
2	11:50	91	32	870	155	715	12.1
3	12:05	91	32	860	155	705	10.25
				860	153.333	706.66	

CONCLUSION

Time for using Solar energy has come and prince40 Concentrators, Scheffler Concentrators" with direct heating have been successfully used in food processing and its time now that Industry takes it up on larger scale and it is bound to succeed because Solar energy not only saves and fuels and protects environment but also brings other advantages like value addition and employment generation at local and rural level and thus ideal for developing countries to change and help the rural population where major percent of the population reside. There are consumers who want to buy solar manufactured products and willing to pay a bit more because it is manufactured in environmentally friendly way.

To make it happen we need more people like Wolfgang Scheffler and DrSeiferts and others, More NGOs like Barli and Eco Center ICNEER which acts as a bridge and facilitators and Entrepreneurs like Ghansyambhai who are willing to take risk and who are passionate about it and willing to try it out and with their input and dedication encourage other to go solar.

RESULT

A. The optical efficiency of PRINCE 40 is- 50.8%
B. The Normalized heat gain is -4744.596kJ
C. Normalized single point efficiency is- 43.93%

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