Thermal Performance Study of Parabolidal Concentrator Solar Cooker

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Abstract

Firewood use for cooking cause deforestation, Commertial fuel is not available and cow dung used for cooking is good fertilizer. Hence if human resources used to collecting fuel can be diverted and used for maximum use of solar energy then it saves conventional fuels. Varieties of solar cooker have been developed, but not in use as expected. But acceptance will increase through serious and continuous program of introduction, education, training and involvement of women folk. Present work involves evaluation of domestic parabolidal solar cooker.

Introduction

There are a variety of type solar cookers: over 65 major design and hundreds of variations of them. The basic principle of all solar cookers are concentrating sunlight, Converting light to heat, trapping heat and plastic sheet, Sunlight.

Designing

Circular dish model-SK14

i. Parabolidal dish is made by joining small pieces of reflector. It was supported firmly with rigid frame.
ii. Reflectivity of material =80.2%
iii. Reflective material of dish = Anodized Hardened Aluminum
iv. Aperture Area= 1.5 sq.m
v. Size of focal spot= 21 cm
vi. Focal length of dish = 28 cm
vii. Manual tracking mechanism is used which allows unrestricted rotation of dish along its horizontal and vertical axis and adjusted in direction normal to direction of sun's rays.
viii. Cooking pot used a pressure cooker with ISI mark and its bottom coated with high temperature resistant black powder.

Methodology

To study performance of solar cooker following formula were used Heat loss factor(FUL)= Mc/A pot T0

Where Apot= Total surface area of cooking pot.sqm.

Mc= Total heat capacity of cooking pot and water.

T0 = time constant for cooling

Thermal Efficiency (Fn) = It is calculated by using following formula

$$Fn=\{\frac{(FUl)Apot}{Aapert}[(\frac{Twi-Ta}{Ib})-[(\frac{Twf-Ta}{Ib})e^{-T/To}]\}\div(1-e^{-T/T0})$$

T**wi** = Temperature of water in the cooking pot at the beginning of the interval.
T**wf** =Temperature of water in the cooking pot at the end of the interval
T = Duration of the interval
I**b** = intensity of beam radiation in incident on the aperture of the concentrator, averaged during the interval
T**a** = Ambient air temperature averaged during the interval.
A**pot** = Total surface area of the cooking pot .
A**aper** = Aperture area of the parabolidal concentrator cooker.

Test Result of Solar Cooker(Thermal Performance Test)						
Cooker Name –SK-14				Test Date – 27/02/2015		
Initial Mass of water in gms = 2000				Mass of water after testing in gms = 1564		
Weight of Empty Aluminum vessel in gms=600				Test Started at 11.55 am		
Water temp. in0 C =19				Ambient temp. in oC =23		
	Time	Water temp	Ambient temp	Irradiance sensor reading in MV	Irradiance in watts/sqm	Speed of Air in m/sec
1	0	19	23	153	765	2.3
2	5	36	23	147	735	4.1
3	10	51	24	143	715	5.2
4	15	67	25	138	790	1.6
5	20	81	25	145	725	4.3
6	25	90	25	148	740	2.9
7	30	94	26	153	765	4.6
8	35	96	27	155	775	3.8
9	40	97	27	149	745	6.2
10	45	96	28	157	785	2.0

11	50	97	27	153	765	1.8
12	55	96	27	150	750	3.8
13	60	96	27	151	755	2.8
Avg Amb. Temp			**26**	**Avg.Isolation**	**747**	**3.4**

Test Result of Solar Cooker

Stagnation Temperature Test-

Cooker Name SK-14	test Date = 27/02/2015
Weight of oil in pan in gms = 400	Test started at 13:15

Tracking : Manual with clutch arrangement

Sr.No.	Time	Oil	Ambient temp	Irradiance sensor reading in MV	Irradiance in watts/sqm	Speed of Air in m/sec
1	0	23	24	156	780	1.2
2	5	55	26	179	895	2.1
3	10	117	27	147	735	2.9
4	15	171	29	146	730	1.2
5	20	208	28	145	725	0.8
6	25	223	29	152	760	1.8
7	30	227	27	159	795	2.3
8	35	226	29	161	805	2.9
9	40	228	30	158	790	1.4
10	45	227	28	161	805	1.1
11	50	228	30	159	795	0.8
12	55	229	29	157	785	0.9
13	60	228	30	158	790	1.3
Max.Stagnation temp.noted in ^{o}C 229				Avg. Isolation	784	

Observation for solar Cooker SK-14

Mass of water evaporated	436 gms
Sensible heat gained by water	588.76 kJ
latent Heat gained by water	985.36 KJ
total Heat gained by water	1574.12 KJ
Heat gained by pot	37.97 KJ
Total Heat gained by pot + water(Mc)	1612.08 KJ
Aperture area of Concentrator(A aper)	1.5 sqm
heat Input	4033.38 KJ
Overall thermal efficiency	0.3997
Overall thermal efficiency in %	39.97 %

Conclusions

Thermal performance study of concentrator cookers of circular dish model has efficiency 39.97%.

References

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