International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 04 Issue: 07 | July -2020 ISSN: 2582-3930

COMPARATIVE STUDY OF REFLECTIVITY OF DIFFERENT REFLECTING MATERIALS USED IN SOLAR CONCENTRATING COLLECTORS

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Abstract

Solar energy is very large, in-exhaustible source of energy. The use of renewable energy is receiving growing interest worldwide. The power received from the sun is 1.8 × 10^{11} MW on the Earth surface which is thousand times greater than all other commercial sources of energy available on the Earth. To harness this free available energy, solar concentrators are used. These concentrators convert solar energy into thermal or heat energy and also convert it into electricity. Some applications of these concentrators are cooking, frying, drying, water heating, steam generation etc. In these solar concentrators, solar radiations fall on reflecting surface and then they are concentrated at single point commonly called focal point. To make concentrating solar power technologies more cost competitive, it is necessary to develop advanced reflector materials that are low in cost and maintain high reflectance for extended lifetimes under severe outdoor environment. The efficiency of these solar concentrators depends on reflecting surface. Good reflecting surface can improve the efficiency of system and it also can increase temperature at focal point. In this research paper, different reflecting materials are tested to find out its reflectivity.

Key Words: Solar concentrators, reflectivity, reflecting material.

Introduction

The reduction in the availability and the ever increasing prices of fossil fuels, as well as the expensive and insufficient electricity supply, are some of the reasons explaining increasing the public awareness regarding the use of alternative cooking method in recent years. In most of the rural areas, the use of wood is more preferred for cooking and this has led to deforestation in many areas. Pollution from fossil fuels and firewood can only be minimized if majority of the people use cleaner and environmentally friendly sources of energy like solar and wind.

India is a country that is blessed by solar energy. The solar energy is available almost throughout the year and can be used as an alternate source input to meet out energy demands. Therefore there is beneficialto utilization of solar energy for different applications. Solar energy is the cheapest, inexhaustible, environmental friendly source and can be used for various domestic and agricultural requirements including cooking, drying, dehydration, heating, cooling and power generation. A major concern of today is the speedily depleting natural energy resources. So it is the utmost need of time to reduce the dependency on non-renewable sources, judiciously using the remaining sources and at the same time switching to new and better alternatives and renewable source of energy.

One of the important applications of solar energy is solar cooking. To cook food we need some form of energy and solar energy presents a feasible alternative over usage of wood, kerosene and other traditionally used fuels in developing countries. Among the different solar thermal applications, solar cooking can be deemed as one of the simple, viable option for utilization of solar energy.

Utilization of solar cookers has many advantages like no recurring costs, high nutritional value of food, potential to reduce labor and high durability, health, saving in time and expenditure of the users and the impact on environment with regard to global climate change, deforestation, and economic deprivation of the poor people.

Solar cookers use reflectors which reflect maximum possible solar radiation on absorber plate thus it is very important to choose the correct reflector for cooker design. There are various types of reflectors that can be employed in the solar cookers like flat plate, compound concentrating collectors, cylindrical parabolic collectors. To make concentrating solar power technologies more cost competitive, it is necessary to develop advanced reflector materials that are low in cost and maintain high reflectance for extended lifetimes under severe outdoor environments.

This research was carried out to evaluate the reflectivity of different reflecting material that produces more heat for cooking of food in solar cooker. High reflecting material can increase the efficiency of solar cooker by generating more heat.

Methodology:

The test procedure recommended by the American Society of Agricultural Engineers (ASAE S580) [2006] was used for reflectivity test of different reflecting material.

Reflecting Material used: Glass mirror, Aluminum sheet, Silver coated aluminum sheet and Aluminum foil.

Reflectivity of these four reflecting material was measured by using pyranometer.

For measurement of reflectivity, following arrangement was done.

Two stands were fabricated, one is for holding the pyranometer parallel to the reflecting material at a distance of about 30 cm with two axis tracking arrangement and the other is to hold the reflecting material parallel to the solar

radiation which was 50 × 30 cm. This stand had a pointer (10- 15 cm long pin) fixed normal to its plane.

Fig. Experimental setup

Procedure: Following procedure was used:
The stand in an open space free from shadow and reflected radiations from the surroundings was placed. The reflecting material on the stand parallel to its plane was fixed. Also one of the pyranometer (P_1) was fixed in such a way that its sensor faced towards the mirror. The solarimeter (S_1) horizontally near the stand for using it as a reference solarimeter was placed.

The stand for normal incidence was adjusted in such a way that shadow of the pointer is not there. The stand was tilted about 10° from the normal position and adjust the position of pyranometer (P_1) on it in such a way that radiation reflected from the reflecting material fall on the pyranometer sensor. The reading R_1 and S_1 of the pyranometers P_1 and solarimeter S_1 respectively were recorded.
Without changing the tilt of the stand, the pyranometer $P_1$was reversed so that its sensor faces the sun and is parallel to the reflecting material. The readings R_2 and S_2 of both the pyranometers P_1 and solarimeter S_1 respectively were recorded. The two readings of the reference solarimeter S_1 (S_1 and S_2) should not have be performed in clear weather and the global radiation recorded should be more than 600 W/m^2
The reflectivity of the materialswas calculated from the below relation,

$$R = \frac{R2}{R1}$$

Where,
R_1 = Reflected rays from surface of material
R_2 = Reflected rays from surface of sun
The test was repeated six times. The average of the six values of the R wasgave the reflectivity of the material.

Result and Discussion:

The experiment on measurement of reflectivity of different material was conducted at Energy Park of CAET-Dapoli, Dr. BSKKV- Dapoli, Ratnagiri.
In table 1 the characteristics of different reflecting material are displaced.

Table 1: Characteristics of reflecting material

Sr. No.	Material	Weight	Cost/sq. m (Rs.)	Characteristics
1	Glass Mirror	Very heavy	150-200	Super reflective, 5 mm thickness, front reflecting surface mirror
2	Aluminum Sheet	Light	75-85	Reflective, Widely available, Commonly used as reflecting material
3	Silver coated Aluminum Sheet	Light	90-120	Reflective, light weight, structurally durable, easily fixed and shaped
4	Aluminum Foil	Super light	40-60	Extremely cheap and widely available

Below graph shows the average reflected rays from surface of material (R_1) and Average reflected rays from surface of sun (R_2) with reference of solar intensity S_1 and S_2 respectively.

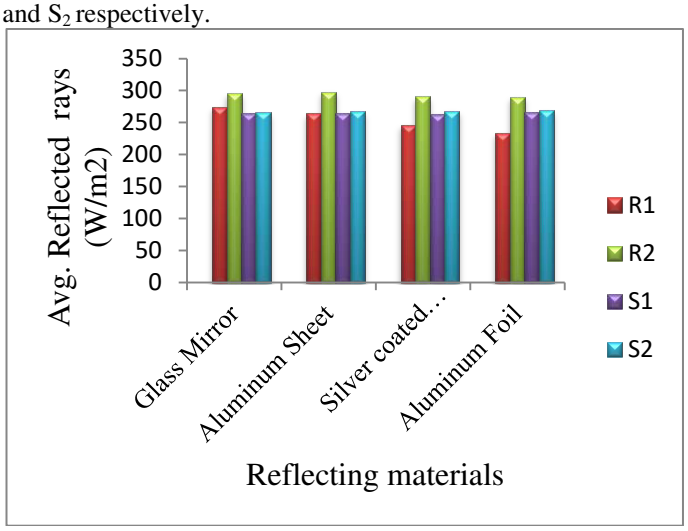

Fig: Experimental data of measurement of reflectivity

From above graph it is observedthat the average value of R_1 for Glass mirror, Aluminum sheet, Silver coated Aluminum sheet and Aluminum foil was 274, 264, 246 and 234 W/m^2 respectively, with reference average solar intensity (S_1) of 265, 261, 260 and 261 W/m^2 respectively and the average value of R_2 was 295, 298, 291 and 290 W/m^2 with reference of average solar intensity (S_2) of 267, 264, 263 and 266 W/m^2 respectively.

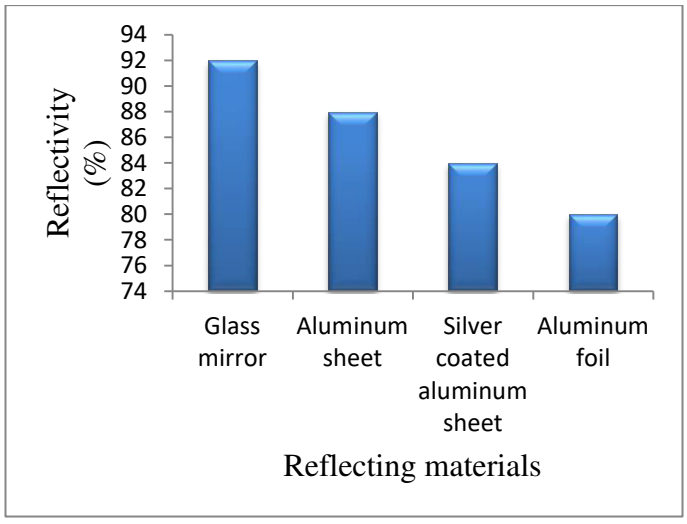

Fig: Reflectivity of different reflecting materials

From abovegraph, it is observed that the glass mirror has highest reflectivity i.e. 92%, below that aluminum sheet has reflectivity of 88%, then aluminum foil has reflectivity of 80% and silver coated aluminum foil has reflectivity of 84%.

Conclusion:

In the present study, reflectivity of four different reflecting materials was measured and the results of the study was revealed that glass mirror has highest reflectivity of about 92%, that the aluminum sheet had reflectivity of 88%, aluminum foil had reflectivity of 80% and silver coated aluminum sheet has reflectivity of 84%. From these resultsit can conclude that glass mirror had highest reflectivity, but its use was not economical and chances of damage were more in glass mirror so instead of glass mirror, aluminum sheet could be used as reflecting material which had reflectivity of 88%. Aluminum sheet was found as light weight, low cost and durable material so aluminum sheet could be used as a reflecting material. Aluminum foil had reflectivity of 80%. This material was also light in weight and low in cost but its surface was not plain, therefore its reflectivity got reduced.

So it can be conclude that aluminum sheet is best reflecting material for concentrating solar cookers.

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